Natural England Commissioned Report NECR229

The translocation of freshwater pearl mussels: a review of reasons, methods and success and a new protocol for England

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Foreword

Natural England commissions a range of reports from external contractors to provide evidence and advice to assist us in our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

Translocation is the intentional collection, movement and release of plants or animals from one or more places to one or different locations. It is normally undertaken in an attempt to establish, re-establish or augment a population i.e. for conservation purposes, but inappropriate translocations can have the potential to cause considerable damage.

The freshwater pearl mussel (*Margaritifera margaritifera*) is threatened throughout its global range. Populations in England have undergone severe declines in recent years and local catchment partnerships are now exploring the need to translocate adult pearl mussels to protect remaining populations.

Translocation is an effective conservation tool but its use either on its own or in conjunction with other conservation solutions needs rigorous justification and is seen as a recourse of last resort.

Natural England is responsible for licensing the taking of protected species from the wild for release elsewhere and for issuing consents for the collection of donor stock and for releases where these take place on protected sites (e.g. Natura, Sites of Special Scientific Interest) and we need a protocol we can refer to in situations which may require the translocation of freshwater peal mussels and which can be applied to any river in England or elsewhere.

To provide evidence to develop our protocol we commissioned a wider review of existing knowledge and experience with translocations from across Europe and North America, in addition to a review of the codes and legislation.

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Further information

This report can be downloaded from the Natural England Access to Evidence Catalogue: **http://publications.naturalengland.org.uk/**. For information on Natural England publications contact the Natural England Enquiry Service on 0845 600 3078 or e-mail **enquiries@naturalengland.org.uk**.

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Glossary

Anterior end - is the shorter end of the shell as measured from the oldest part of the mussel's shell

Brooding period - length of time that glochidia remain within the body of a gravid pearl mussel

Encystment - process in which pearl mussel glochidia attach to the gills of their salmonid hosts

Filter feeding - process by which pearl mussels feed by straining suspended matter and food particles from water, typically passing the water over a specialized filtering structure

Glochidium (plural 'glochidia') - larva of *Margaritifera*

Glochidial release - process by which gravid pearl mussels release glochidia into the water

Gravid - carrying eggs or developing young

IUCN - The International Union for Conservation of Nature

Moribund - being in the state of dying, approaching death

Recruitment - survival of juvenile pearl mussels and their addition to a population

Redox potential – tendency of a substance to gain or lose electrons. In the context of this report, redox measurements of the stream-bed water at the typical depth of juvenile mussels are used as indicators of oxic (high Eh) or anoxic (low Eh) conditions

Reproductively viable - able to maintain a self-sustaining population without the addition of new genetic material from outside the system

Riparian zone - area of land adjoining a river channel (including the river bank) capable of directly influencing the condition of the aquatic ecosystem (e.g. by shading and leaf litter input)

Salmonid host - essential host for pearl mussel glochidia, in Europe usually Atlantic salmon (*Salmo salar*) or brown trout (*Salmo trutta*)

Translocation - is the intentional collection, and movement of plants or animals from one area, with release in another

1. Introduction

1.1 The freshwater pearl mussel (*Margaritifera margaritifera*) is endangered at a global scale and declining throughout its UK range. Populations in England have undergone severe declines in recent years as a result of a combination of factors including direct exploitation, physical habitat degradation, nutrient enrichment, siltation and pollution. Changing climatic conditions may also be a factor and will likely pose further challenge in the future.

1.2 In order to protect the remaining populations, the statutory conservation agencies in England and Wales have identified the need to work in sub-catchments that are amenable to improvement and where habitat restoration work can be prioritised (Barnfather *et al.,* 2010). Local catchment partnerships are now exploring the need to translocate adult pearl mussels to protect threatened populations and to introduce juvenile mussels to identified receptor / recovery sites as potential management solutions.

Freshwater pearl mussel (River Ehen, Cumbria) © Ian Killeen

Aims and objectives

1.3 Natural England requires the production of a protocol that can be referred to in situations which may require the translocation of freshwater peal mussels (*Margaritifera margaritifera*) and which is applicable to any river in England or elsewhere. In order to provide this information, it is necessary to carry out a wider review of existing knowledge and experience with translocations, in addition to a review of codes and legislation. Based upon this premise the review will cover:

- Published codes providing reasons and acceptable cases for translocations
- Legislation
- Reasons for translocating *Margaritifera*
- History of translocation results for *Margaritifera*
- Information obtained from mussel researchers in Europe and America
- Factors to consider in mussel translocations
- Studies needed in advance of the translocation process
- Protocol for translocation and subsequent monitoring

2. Existing codes and relevant legislation

2.1. Translocation is the intentional collection, and movement of plants or animals from one area, with release in another. It is normally undertaken in an attempt to establish, re-establish or augment a population (Griffith *et al.* 1989), i.e. for conservation purposes. Inappropriate translocations can have the potential to cause considerable damage (Hodder & Bullock 1997), for example adverse effects on species and habitat at release sites, genetic out-breeding and hybridisation, impact on donor sites, unwanted competition and/or outbreak of disease and predation (Waters & Lawton, 2011).

IUCN guidelines for reintroductions and conservation translocations

2.2. The IUCN Species Survival Commission has published **guidelines for reintroductions and conservation translocations** (IUCN/SSC, 2013). The guidelines provide a basis for deciding when translocation is an acceptable option. They specify that risk analysis around a translocation should be proportional to the presumed risks. Justification requires an especially high level of confidence regarding the organisms' likely performance after release, including over the long-term, with reassurance on its acceptability from the perspective of the release area's ecology, and the social and economic interests of its human communities. It notes that in any decision on whether to translocate or not, the absolute level of risk must be balanced against the scale of expected benefits. It concludes that where a high degree of uncertainty remains or it is not possible to assess reliably that a conservation introduction presents low risks, it should not proceed, and alternative conservation solutions should be sought (if appropriate).

A code for conservation translocations - Scotland

2.3. Building on the IUCN guidelines, a code for conservation translocations has been produced for Scotland (National Species Reintroduction Forum, 2014). **The Scottish code** has seven points to follow from initial evaluation to post translocation monitoring:

1) Evaluate whether a conservation translocation is the best option - Undertake an assessment of whether other management actions may be more appropriate.
2) Where translocation is the best option, develop a plan to deliver a defined conservation benefit – Establish the desired outcome: this should be to improve the conservation status of the focal species/habitat by enabling more individuals/populations to survive in the wild; and also to provide wider benefits to biodiversity and people.
3) Stay legal: obtain necessary permissions and adhere to relevant legislation.
4) Maximise chances of successful establishment of the translocated population – All translocations must be grounded in a thorough knowledge of the species' ecological requirements.
5) Minimise the risks of harm to biodiversity – Do not remove organisms from a donor site if it will place that population at risk, adopt high standards of animal welfare, and adopt strategies to avoid stress, harm or mortality during the translocation and subsequent release and monitoring, evaluate whether establishment at the release site is likely to

lead to unacceptable, negative effects on species, habitats or the wider ecosystem, and do not proceed if this is likely to occur.

6) Maximise societal benefits and minimise conflict with other land-users - consult with other land-users and stakeholders to fully understand the potential socioeconomic consequences of conservation translocations.

7) Record translocations and monitor, evaluate and communicate outcomes – monitor translocations to evaluate success and to inform any necessary ongoing management interventions, document the translocation and share findings to inform future strategies and projects.

A screening tool for identifying receptor sites - England

2.4. A screening tool has been produced for Natural England (Atkins 2012) to help the assessment of sites according to their potential to be receptor locations for freshwater pearl mussels as a management measure. The tool was originally developed as part of the River Clun SSSI/SAC Restoration Strategy in Shropshire. This is given in full in **Appendix 2**.

Chartered Institute of Ecology and Environmental Management (CIEEM)

2.5. The professional institute that covers professional field ecologists and environmental managers have addressed translocation on two occasions, in 2004 (Rooney *et al.* 2005) and in 2015 (Hollingsworth & Gaywood 2015). On both occasions the guidance presented followed the most recent IUCN protocols. The CIEEM publication "In practice" is one potential forum for the publication of translocation projects and their monitoring, where the manager feels that the information is not quite sufficient for a peer-reviewed journal, but would be a useful addition to the body of knowledge on translocation outcomes.

European Committee for Standardization (CEN)

2.6. A Guidance Standard on freshwater pearl mussel (*Margaritifera margaritifera*) populations has been prepared by a group of European experts on the species for the European Committee for Standardization (ECS 2015). This document is currently in final draft form and is awaiting a vote from the countries included in the standardization process to proceed with its publication. This European Standard provides guidance on methods for monitoring freshwater pearl mussel populations and the environmental characteristics important for maintaining populations in favourable condition. The standard is based on best practice developed and used by *Margaritifera* experts in Europe, and describes approaches that individual countries have adopted for survey, data analysis and condition assessment. The standard does not deal with translocation or any conservation management or rehabilitation, as they did not fall within the remit of the scope of the standard.

Legislation and licensing

2.7. The freshwater pearl mussel and it's habitat are fully protected by law in the UK. Further information on the legislation and licensing arrangements in England is given in full in **Appendix 3**. Key points are summarized below:

- The freshwater pearl mussel is listed under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended) and is covered by the provisions of section 9 of the Act. Details of the legislation can be found at: **http://www.legislation.gov.uk/ukpga/1981/69/contents**

- The freshwater pearl mussel is also listed under the European Habitats Directive 1992 (Annexes II and V) and is protected by the Conservation of Habitats and Species Regulations 2010 ("the Habitat Regulations"). Details of the legislation can be found at: **http://www.legislation.gov.uk/uksi/2010/490/pdfs/uksi_20100490_en.pdf**

Protected sites

2.8. Translocations may have a significant effect on protected sites (e.g. Special Areas of Conservation (SACs) and Sites of Special Scientific Interest (SSSIs)), for example a translocated species could alter the quality of the qualifying habitat, or people involved in the translocation might disturb other qualifying species. In these situations 'consent' is likely to be required from the regulatory authority.

Natural England is responsible for issuing 'consents' for the collection of donor stock and for releases where these take place on protected sites in England. Further information about the process for getting consent can be found at: **https://www.gov.uk/guidance/protected-areas-sites-of-special-scientific-interest**

Licensing

2.9. Translocations of protected species will require a 'wildlife licence' from the regulatory authority. Where a licence is required, it will typically be assessed against the following considerations:

- Is there an appropriate legal purpose to the translocation? (In the case of a conservation translocation the answer would be yes, since conservation is a legal purpose)
- What other solutions have been considered and why have these been discounted?
- What is the impact of the proposed translocation on the conservation status of the population/species concerned?

For more information regarding wildlife licensing visit the 'Gov.uk' website at: **https://www.gov.uk/guidance/wildlife-licences**

Habitat's Directive Appropriate Assessment

2.10. Where a translocation is being considered because of a threat from a source other than those that could be considered to be "natural causes", as part of a plan or project e.g. during the repair of a bridge where there may be direct impact on some mussels, the potential impact of the translocation of the mussels should be considered as part of a Habitats Directive Assessment, which would then be used to inform the Appropriate Assessment undertaken by the regulating authority under Article 6 of the Habitat's Directive. Guidance on Article 6 is available (European Communities, 2000; 2002).

If a translocation is proposed within a population that is qualifying interest of an SAC for direct 'conservation purposes', an Appropriate Assessment is not required. However, as translocations can lead to negative effects on the population of an endangered species, following the guidance is very important. In addition, the background to the translocation, the investigative steps and the decisions made on the numbers of mussels moved, their donor and receptor sites and related decisions made should be fully documented and a monitoring plan proposed and implemented, in order to ensure best conservation practice. Such an approach will also assist with generating better long term information on the practice of translocation.

Reference should be made to the standing advice produced by Natural England, the Environment Agency and Defra to assess the effect of development activities on freshwater pearl mussels. Further details can be found at: **https://www.gov.uk/guidance/freshwater-pearl-mussel-surveys-and-mitigation-for-development-projects**

3. Reasons for translocation

3.1. Mussel translocations are undertaken for a number of reasons. Historically there are lots of old accounts in Europe, some dating back several hundred years, where wealthy landowners attempted to augment their mussel stocks for pearls but of course there are no exact data about numbers relocated and failure or success. There are also (unsubstantiated) rumours that some known populations were the result of deliberate introductions. Most modern translocations have been the result of mitigation measures and usually involve relocation within the same waterbody or catchment (intra-river). Most have involved movements of less than a few kilometres although there is one case in Sweden where mussels were moved over 100km. There are also a small number of examples of re-introductions where mussels have been moved from healthy populations in an attempt to repopulate rivers in which the mussels had become extinct (inter-river).

3.2. Thanks to the wide protection that *Margaritifera* has across its range, the potential reasons for modern translocations are out of concern for the protection from danger and the improvement of future prospects of the population. The main reasons for proposed translocations are given below.

1. **Movement of mussels from their native river into captive breeding facilities (STRATEGY DRIVEN)**

   This translocation is considered where there has been a significant loss of survival of younger generations of mussels in a population, and a new generation needs to be maintained ex-situ until they can cope with the habitat conditions in their native river (i.e. beyond the stage where they are fully buried in the substrate).

2. **Movement of mussels from captive breeding facilities back to their native river (STRATEGY DRIVEN)**

   When captive breeding efforts are finished, adult mussels or their offspring that have been held in captivity may be returned to their native river.

3. **Movement of mussels within a river to easy access points for bankside encystment (STRATEGY DRIVEN)**

   In situations of very low populations of scattered individuals, but where catchment rehabilitation has occurred and river bed conditions have improved, bankside encystment may be successful. In this case it may be desirable to create a "nursery" area of brooding adults for ease of access for bankside encystment. This is often a temporary translocation conducted to facilitate management.

4. **Movement of mussels within a river due to imminent danger from accidental damage or pollution event (EMERGENCY DRIVEN)**

   There are a number of records of emergency mussel translocation following e.g. slurry spill, quarry bund collapse, tanker accident. These translocations move mussels farther than those considered as a "rescue" of mussels stranded by drought or bank fall, where habitat is available adjacent to the emergency. In the case of pollution, mussels need to be moved out of danger, but the emergency nature of the movement often makes it difficult to make a detailed choice as to where to translocate. There is generally no time to mark or define translocation receptor sites, making it difficult to monitor the outcomes for the translocated mussels.

5. **Movement of mussels within a river as mitigation prior to imminent danger from direct or indirect damage from permitted plans or projects (mitigation measure) (LEGALLY DRIVEN)**

   This type of translocation is rare due to the difficulty in demonstrating that no significant impact would occur in removing mussels from an area that is planned to disturbed. These translocations are generally avoided due to the cost of the efforts required to reach the level of scientific evidence needed to satisfy the legal requirements of the species.

6. **Movement of mussels within a river from areas of chronically deteriorating catchment or river conditions (DONOR SITE STRATEGY DRIVEN)**

   This is also a very rare consideration, as mussels would need to be in danger of death in order to consider translocation on these grounds alone without first addressing the causes of decline.

7. **Movement of mussels within a river from reaches with no host fish to places with better host fish populations (DONOR SITE STRATEGY DRIVEN)**

   This is a very specific situation, where the life cycle of the mussels in part of a population cannot be completed through physical or chemical (e.g. acidification in Sweden) restrictions.

8. **Movement of mussels within a river to areas of rehabilitated habitat where prior negative effects have been removed in conservation projects (RECEPTOR SITE STRATEGY DRIVEN)**

   This translocation exercise is a final step in a strategy for catchment or other improvements leading to habitats where mussels are likely to live sustainably and where survival is judged more likely in the rehabilitated site compared with current mussel locations.

9. **Movement of mussels within a river as a conservation action to move mussels upstream from estuarine habitats or from the lowest point of rivers beyond which survival is unlikely (DONOR SITE STRATEGY DRIVEN)**

   In catchments where stable mussel habitat has been compromised, mussels can be washed downstream beyond the limit of their tolerance of salinity, or into larger water bodies that do not support *Margaritifera*. Translocating them into mussel habitat upstream could prevent their loss.

10. **Movement of mussels within a river to aggregate widely dispersed mussels (STRATEGY DRIVEN)**

    In very low density populations, mussels may become very sparse and live as isolated individuals spread out through wide areas of river. Consideration has been given to aggregating isolated mussels into pockets to support fertilization of female mussels and thus improve recruitment potential.

4. History of translocation results for *Margaritifera*

4.1. Translocations of *Margaritifera* have notoriously poor results, but (possibly because of such negative results) have rarely been published outside of grey literature, and rarely with exact enough details to allow analysis of causal factors of loss. For example, Valovirta (1998) reports that mussels translocated to a different river had a much worse fate than if translocated within their own river of origin, but with no details or causal factors.

4.2. **Appendix 1** gives case studies of a number of translocations we were able to locate in literature or from unpublished reports and personal comments provided by our fellow mussel researchers in Europe and America. These results are summarized in **Table 1** below. From 25 examples with sufficient information, the overall mean loss from receptor sites of translocated mussels amount to 62% [1], monitoring recounts having been undertaken from as little as three weeks post translocation up to 10 years post movement. It should be noted that the number of mussels involved in these translocations is small and makes assessment of survival difficult. While the information is sparse, the summary correlations demonstrate two useful relationships. One is presented in **Figure 1**, comparing the outcomes by whether the translocation was within the same river, or into a different water body. Valovirta (1998) reported 90% short term survival for intra-river translocation, the short term survival for inter-river translocation was 50%. There are no longer term data from these translocations. However, the results from the information available for this document shows that the maximum, mean and minimum percentages of translocation mussels not found during monitoring surveys were almost identical, and thus translocation of mussels within their native river is not necessarily low risk compared with their re-introduction to a new river.

The second correlation is between the outcome in mussels found during monitoring and the length of time between the monitoring survey and the translocation. The monitoring surveys varied between one month and 10 years post translocation, and **Figure 2** shows a reasonable correlation (R2=0.4624) between loss and length of time post translocation. The results suggest that translocated mussels may continue to be lost over time and are not necessarily safe in their new locations if they survive there in the short term. While there is no direct experimental comparison between the percentage of translocated mussels that are re-found and the equivalent in mussels that have not been moved (a study of this nature is underway), there are studies that have demonstrated that mussels in the least stressed condition and the best quality habitats move very little from their native beds.

4.3. Mussels moved to captive breeding facilities may not necessarily be low risk than equivalent sets of mussels left in their native water, even if the native environment for those mussels was sub-optimal in condition. From a total of 389 individual mussels translocated to captive breeding facilities from 11 different mussel populations, there was an average of 29% mortality over 5 years, averaging 5.8% loss each year (data from Moorkens, 2015; Miles & Sweeting, 2010; Killeen 2013; Lavictoire, pers. comm.) compared to c.1%-3% considered indicative of natural losses. Further loss has occurred when mussels that had been kept in captivity for long

[1] The term “loss” in this document refers to mussels not being relocated during monitoring surveys at the site of translocation. The fate of the mussels is not generally known, unless there are dead shells found during the survey. Lost mussels may have been washed downstream alive, or they may have died and their shells have been subsequently washed away.

periods (years) were translocated back to their native river - these translocations are consistent with the worst translocation records, including all the 100% losses.

Figure 1: Comparison of percentage of mussels re-found between intra and inter- river translocations

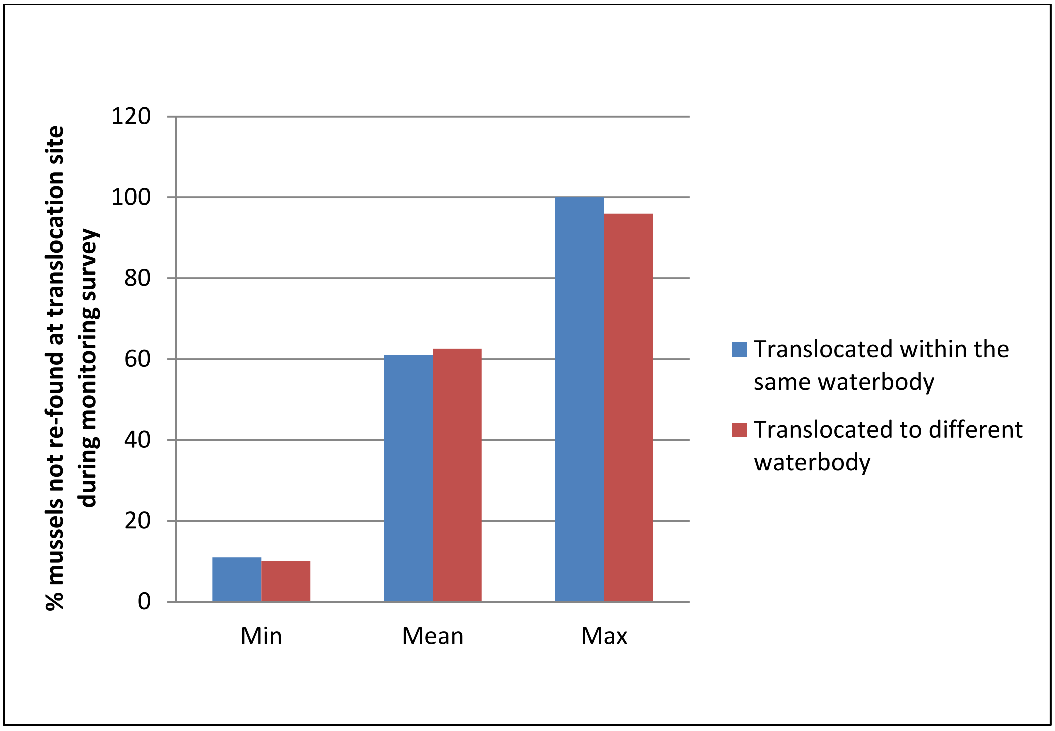


Figure 2: Comparison of percentage of mussels re-found and length of time after translocation

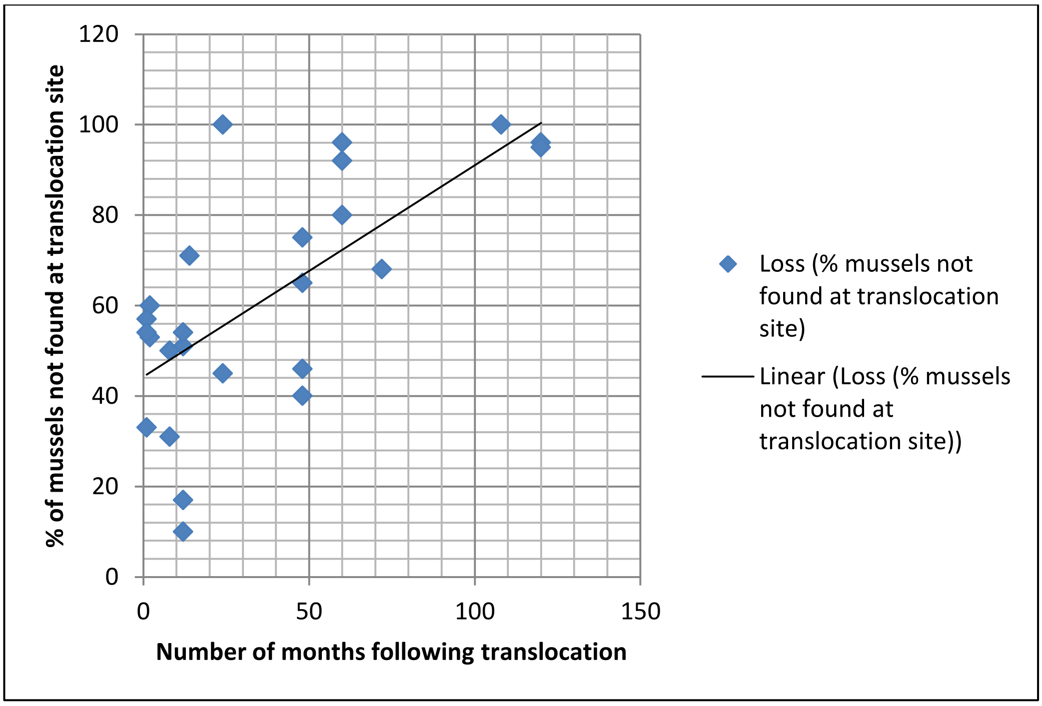


Table 1: Summary of translocations

Where results have not been published, the exact locations of mussel populations have been protected.

Country	Catchment/ River	Translocation reason	Date of translocation	Date of monitoring	Outcome (as numbers re-found unless otherwise stated)	Notes	Reference
England	Torridge, Devon	Gauging Station upgrade	August 2002	+ 2 years	0% found (0 of 4)	Low flow noted in 2004	Lane pers. comm.
England	Torridge, Devon	Return after captive breeding	June 2014	August 2014	At least 60% loss	Mussels & river in relatively poor condition	Killeen 2015
England	Kent, Cumbria	In-channel de-silting works	May 2011 (1st batch) June 2012 (2nd batch)	+1 year + 5 years + 3 years + 5 years	75% re-found after 1 year, 33% re-found 5 years (12 of 36) 90% re-found after 3 years, 45% re-found after 5 years (4 of 9)	45 mussels translocated to good habitat upstream	Measures unpublished reports 2011 - 2016
England	Lune, Cumbria	Return after captive breeding	April 2014	+1 month	43% found (3 of 7)	Mussels & river in relatively poor condition	Kahl pers. comm.
Wales	Afon Ddu, Snowdonia	Watercourse and adjacent land drainage	July 1996	+2 months	47% found (162 of 342)	Mussels & river in relatively poor condition	Killeen *et al.* 1998
Wales	Teifi, Cardiganshire	Experiment	1997	2006, +9 years	0% found (0 of 12)	Mussels moved to better habitat	Killeen 2007
Ireland	Nore River, Laois	Return from captive breeding	July 2014	+ 1 month	46% found (6 of 13)	Mussels & river in relatively poor condition	Moorkens 2015
Ireland	River B, Kerry	Bridge upgrade works	Sept 2013	+8 months	69% found (35 of 51)		Moorkens pers. comm.
Ireland	River D, Kerry	Experiment	September 2015	+ 3 weeks	67% found (20 of 30)		Moorkens pers. comm.

Country	Catchment/ River	Translocation reason	Date of translocation	Date of monitoring	Outcome (as numbers re-found unless otherwise stated)	Notes	Reference
Scotland	Speyside	Reintroduction to tributary	2005	+ 5 years, + 10 years	8% re-found after 5 years, 4% re-found after 10 years	750 mussels moved	Sime pers. comm.
Scotland	Deeside	Reintroduction to tributary	2005	+ 5 years, + 10 years	20% re-found after 5 years, 5% re-found after 10 years	100 mussels moved	Sime pers. comm.
Scotland	Lochaber	Reintroduction	2009	+ 1 year, + 6 years	49% re-found after 1 year, 32% re-found after 6 years	200 mussels moved	Sime pers. comm.
Scotland	Stac Burn	Experiment	1982	+ 14 months (1st), + 8 months (2nd)	71% (of 20) lost from 1st batch, 50% loss (of 20) from 2nd batch	Mussels moved to different habitat	Young & Williams 1983
Scotland	West Sutherland	Mitigation	1999/2000	+ 2 years	55% (of 695) re-found		Sime pers. comm.
Scotland	Ross-shire	Mitigation	1999		No further data		Sime pers. comm.
Scotland	Inverpolly	Reintroduction	2013	+ 1 year	90% (of c. 30) re-found		Sime pers. comm.
Germany	River A, Bavaria	Quarry threat	2006-2008	+ 4 years	25% found (13 of 53)	Mussels translocated to good habitat upstream	Schmidt, unpublished report
Germany	River B, Bavaria	Motorway construction	1995	+ 5 years	60% found (242/400)	Movement was 3km upstream to similar habitat	Schmidt, unpublished report
Germany	River C, Bavaria	Translocation to u/s of hydropower station	September 2009	+ 5 years	4% found (6 of 139)	Mussels moved to better habitat	Schmidt, unpublished report
France	Brittany	Ease of management for	2012-2014	2015	100% survival (10 individuals)	Mussels not moved far (a few metres to	Capoulade pers. comm.

Country	Catchment/ River	Translocation reason	Date of translocation	Date of monitoring	Outcome (as numbers re-found unless otherwise stated)	Notes	Reference
		captive breeding				1 km)	
Finland	Unknown Rivers	Restoration restocking	1980 - 1995	Unknown	Unknown, Av. 10% mortality in same river, 50% mortality between rivers	No details or methodology or timescales. Translocation was the “last resort”	Valovirta & Yrjänä 1996
Sweden	River A	Unclear	2012	+ 7 months	25 mussels moved but placed within crayfish cages where they could not be washed out. 100% re-found, no later data	232 further mussels moved but not yet monitored	Olofsson pers. comm.
Sweden	River B	Reintroduction	October 2015	Planned for 2016	None yet	483 mussels taken from a tributary	Olofsson pers. comm.
Sweden	River C	Reintroduction to restored habitat	After 2009	None planned		950 mussels moved 110km	Olofsson pers. comm.
Sweden	River D	Reintroduction	2007	2008-2012	65% loss (of 300) from site 1, 40% loss (of 400) from site 2	Frozen bed part implicated in the loss	Olofsson pers. comm.
Sweden	River E	Reintroduction	2010	+ 2, + 3, and + 4 years	46% loss (of 48) after 4 years		Olofsson pers. comm.
Norway	River A	?	?	+ 1 year	83% (of 88) re-found (range 53-100% in 6 sites)	Moved 1km in same river	Larssen 2015
Norway	River B	?	?	+ 1 year	46% (of 250) re-found (range 52-80% in 5 sites)	Moved 2.5km from a tributary	Larssen 2015
Norway	River C	?	?	+ 1 year	46% (of 406) re-found (range 5-80% in 10 sites)	moved 100-350m u/s to a restored channel	Larssen 2015

Country	Catchment/ River	Translocation reason	Date of translocation	Date of monitoring	Outcome (as numbers re-found unless otherwise stated)	Notes	Reference
USA	(*Cumberlandia monodonta*) Mississippi	Bridge works	2015	+ 3 weeks	50% found (5 of 10)	Mussels moved to better habitat	Ecological Specialists, O'Fallon, Missouri
USA	(*Lampsilis higginsi*) St Croix River	Bridge construction	November 1988	September 1991	90% mortality (37 of 42 dead)		

5. Factors to consider in mussel translocations

5.1. As the number of conservation interventions increase, improving the success of translocations efforts and understanding the reasons for translocation failures is essential.

5.2. With a small data set and a wide range of potential confounding factors, it is difficult to isolate key causes of problems for survival of mussels in the translocation receptor site. Most of the published material refers not to *Margaritifera*, but to less sensitive unionid mussels, so has little empirical value for *Margaritifera*, but has good applied value, as the various potential contributions to negative effects would be applicable to other bivalve species with buried juveniles.

Waller *et al.* (1993) provides useful guidance on relocating translocated mussels; Waller *et al.* (1995) and Cope *et al.* (2003) deal with handling and transport protocols for mussels during the translocation process and Waller *et al.* (1999) reports on behavioural responses to disturbance. Bartsch *et al.* (2000) and Greseth *et al.* (2003) both studied the stress and mortality responses for different times of exposure from water and emersions at different air temperatures. Inadequate receptor habitat choice in the translocation process is considered by Dunn *et al.* (2000). Cope *et al.* (2003) reviewed a number of other factors that may have contributed to mussel stress. Although the exact responses of different species differ, it is likely that due to the higher sensitivity *Margaritifera* over other unionid species, the stress responses demonstrated in less sensitive species are likely to occur as least as badly in the pearl mussel. The papers are particularly helpful in providing robust methodologies for monitoring studies.

5.3. There is strong potential for failure to occur due to circumstances linked to the effects of chronic stress during translocation and establishment phase (Dickens *et al.* 2010, Teixerra *et al.* 2007). The survival of translocated mussels is ultimately a function of their quality and physiological condition upon movement and it has been recognised that mussels can suffer from a loss in condition following relocation. Translocation-induced stress through the capture, handling, captivity and transportation increases the overall vulnerability of individuals (e.g. risk of predation, increased susceptibility to disease or dislodgement post-release) and as a result, decreases the probability of that the population will become self-sustaining. However, stress does not doom an animal to post-release failure or preclude translocation as a conservation tool. There is an urgent need for further empirical studies to examine the stresses caused during animal relocations whereby sources of stress can be identified to minimize both the short and long-term effects.

5.4. **Table 2** outlines the key issues that can contribute to losses, based on published data, translocation protocols and *Margaritifera* ecological requirements (IUCN/SSC, 2013; National Species Reintroduction Forum, 2014; ECS (2015), Moorkens *et al.,* 2007; Moorkens, 2010; Bauer & Wächtler, 2001; Farris & Van Hassel (2007), Preston *et al*., 2010 and the American publications referenced in **Section 8**).

Table 2: Factors that can contribute to poor translocation outcomes

Factor Number	Factor	Potential cause of stress
1	Stress levels of donor mussels	Even when mussel habitat is in good condition, a prior negative event (e.g. a severe low flow) can leave mussel individuals in a stressed condition and less resilient to handling and removal to a new environment. Where mussels are in chronically poor condition they have very little resilience to change in their environment.
2	Quality of donor habitat	Where donor habitat is excellent, translocated mussels may become stressed by responding to being moved to less optimum habitat (e.g. by lifting out of the substrate). Where donor habitat is sub-optimal, mussels may already be in poor condition and not have the ability to adapt to new environment.
3	Collection and handling quality	Although they appear to be robust, mussels are easily stressed by over-handling, the period of emersion, and the quality of the temporary transport environment. Handling during collection, transportation and release is unavoidable but it is evidently important to minimize handling stress.
4	Marking of mussels	In order to monitor translocation success, it is important to be able to clearly mark the mussels. This requires emersion of mussels to dry the shells to label them, which can be a source of stress.
5	Ease of transfer journey	The logistics of how the mussels have to be carried over land and road, the smoothness of the journey and the distance and time needed all contribute to stress levels.
6	Flow pattern differences in donor / receptor habitats	Mussels conditioned to living in fast flows will have strong muscular strength and may pull themselves out of slower flow areas in an attempt to move back to faster flows. Mussels conditioned to slower flows may not have the muscle tone quality to withstand faster flows and may be easily scoured out of the river bed and washed downstream.
7	Innate "righting response"	When mussels are "planted" in their normal two thirds buried position, they have an innate response to pull themselves out of the substrate and rebury themselves. This involves an additional stress and expense of energy reserves.
8	Flow conditions on the day or subsequent days	If translocations are made during high flow conditions or if flows increase significantly following translocation, the mussels are in higher danger of being washed downstream, especially if it follows a "righting" response.
9	Water temperature	Mussels have reduced metabolism and thus ability to move, burrow, right, and otherwise adjust to a more favourable position with decreasing water temperature. Very high temperatures are associated with oxygen reduction and mussel stress.
10	Time of year	Mussels have a complex life cycle and spend a high percentage of the year in gamete production. Females brood larval glochidia in their gills between June and September during which time they have reduced capacity for oxygen uptake and are very vulnerable to stress.
11	Similarity of receptor site	As mussels become adapted to their immediate environment, and most do not move during their lifetime, stress can occur from an inability to adapt to a change in flow, depth, turbidity and nutrient levels and of physical substrate type. Thus even a movement from poor habitat to good habitat may have an inevitable intrinsic level of stress.
12	Quality of receptor site	The correct choice of receptor site on a macro and micro scale presents the greatest challenge as all the aspects of appropriate macro and micro habitat need to be present, including appropriate flows at all times of year,

Factor Number	Factor	Potential cause of stress
		suitable substrate conditions for adult and juvenile mussels, appropriate local hydrological function including provision of juvenile food sources, appropriate host fish densities and conditions appropriate to young host fish congregating close to mussels, juvenile mussel habitat in areas where host fish are likely to congregate in early summer, and the stability to maintain their ideal conditions without interruption for at least ten year intervals (time needed for juvenile mussels to be robust enough to withstand flowing open water).
13	Genetic suitability (mussels and fish)	The translocation of mussels should not compromise the genetic component of the receptor site, e.g. it should not bring a different genetic profile to an area that already has mussels of a different genetic adaptation. The translocated mussels should be demonstrated to be compatible with the host fish strain of the receptor locations.
14	Phenotypic [2] suitability	Mussel shape is relatively plastic and adult mussels can form shapes that are well adapted to their river bed conditions, particularly their flow and substrate burial conditions. Preston *et al.* (2010) recommend that phenotypic characteristics and particularly shell shape variation is taken into consideration when considering the translocation of adult *Margaritifera.*
15	Future prospects	Any translocation receptor site should have long term resilience and not be likely to be especially vulnerable to the effects of climate change or in an area zoned for intended intensification of development.

5.5. The recent and long term condition of mussels to be translocated is clearly of great importance, and the worst translocation outcomes in the short term are associated with the movement of mussels that are already stressed. However, the correct choice of receptor site on a macro and micro scale does present the greatest challenge for long term translocation success, as it requires a large quantity of information on how the translocation site behaves in short and long term flow conditions. If an inappropriate receptor site is chosen the mussels would probably be safer in their original location.

[2] The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences.

6. Balancing the benefits and dangers of translocation – the decision making process

6.1. The evidence available to date from translocations made for various reasons underline how high risk it is as a management tool. The conclusion of Cosgrove and Hastie (2001) that mussel translocation "*has been little used and should be considered experimental and last resort*" is still as relevant fifteen years later. If anything, there are even more reasons to be wary as the research on flow, velocities, hydrology, hydraulics and geomorphology have progressed.

Therefore, a detailed understanding of translocation and receptor habitats, the condition of the mussels, and the appropriateness of the premise for the translocation is important to document. In the case of viable mussel population, detailed consideration must be given to finding, moving and locating appropriate receptor sites for juvenile mussels as well as for adults.

When is translocation an appropriate action?

6.2. The main reasons for proposed translocations as outlined in **Section 3** are considered for appropriateness.

6.2.1. Movement of mussels from their native river into captive breeding facilities

There has been much interest in the UK and Europe in captive breeding mussels to generate stocks for population restoration. This is aimed at slowing or halting the decline of *M. margaritifera* by supplementing remnant populations and extending the species' current range to sites were it existed historically but is now locally extinct. However, few studies have assessed the efficacy of releasing captive-bred freshwater pearl mussels into the wild (e.g. Buddensiek 1995), and therefore little data exists on growth and survival.

The semi-permanent removal of remaining mussels from their native river into captivity should be seen as a last resort action and be considered in situations only where the estimated time for catchment rehabilitation is longer than the estimated lifespan of the mussel population, based on the demographic profile of the population.

6.2.2. Movement of mussels from captive breeding facilities back to their native river

Where a captive breeding programme has been completed and adult mussels have been in captivity on a semi-permanent basis for some time (years) translocation could result in high mortality. Captive mussels would firstly require some form of "conditioning" to improve their fitness and response to higher flows such as placing them in flume tanks (see photos below).

Due to the added potential that captive-maintained mussels may be harbouring pathogens not encountered in the native river and have been maintained in close proximity to captive-reared salmonid fish, a risk assessment of releasing pathogens to native waters via the translocation process should be undertaken. Receptor sites should be chosen in potential habitat that is not occupied by other mussels, so that the translocated mussels can be kept away from other mussel individuals.

Conditioning flume tanks, River Nore mussels, Ireland © Moorkens, E.A.

6.2.3. Movement of mussels within a river to easy access points for bankside encystment

This translocation has been used in continental Europe in order to maintain mussels in their native habitat but to allow easy access to mussels in the short time period when glochidia are naturally released in order to ensure good encystment of fish. This technique is more appropriate to continental rivers with small populations rather than the upland spate rivers of northern populations, as the flow regime may be more even and translocations less stressful for mussels. Choosing an appropriate time for mussel movement is important in this circumstance as late movement of mussels may result in aborted glochidial loads. As with all bankside encystment programmes, the cause of mussel declines need to have been already removed and catchment rehabilitation must have reached a level where the habitat can sustain juveniles to adulthood.

6.2.4. Movement of mussels within a river due to imminent danger from accidental damage or pollution event

This translocation is considered in the aftermath of accidental damage or pollution. It is very unlikely that mussels in the path of pollution can be moved in advance of damage. The value of translocation after mussels have encountered serious pollution is dubious. In the severest of circumstances, the mussels may have been killed or are likely to die. Where mussels have encountered sub-lethal damage, their best chance is likely to be to be left undisturbed to recover over time. Moving stressed mussels to a new habitat area may act as an additional cumulative stress, leading to even worse outcomes.

An exception would be where mussels have been buried under smothering material, and thus would continue to be stressed by the causative factor. In this case the risk of movement may be lower than the “do nothing” response. The health and safety of human workers should always be assessed as part of any options being considered, and this is particularly important where toxic or pathogenic pollution is involved.

Wildlife crime investigation by the police and the conservation agencies will determine options for rescuing mussels in these situations and the risks involved in moving mussels.

6.2.5. Movement of mussels within a river as mitigation prior to imminent danger from direct or indirect damage from permitted plans or projects (mitigation measure).

Cosgrove and Hastie (2001) considered that in exceptional circumstances where a project requires temporary damage to a site, but ensures that full restoration of habitat will occur, the translocation of small numbers of mussels could be considered. Their premise included that the river manager should commit to a recovery and monitoring programme, and that the information on the success or failure of the translocation should be made available to inform future management decisions.

Permanent damage of mussel habitat may be unavoidable for some plans or projects. For protected or important sites, this should not be permitted (as expressed by Cosgrove and Hastie, 2001), and in exceptional circumstances there are legal mechanisms that can address compensation for damage, if such compensation is possible (Habitats Directive Article 6.4 "*imperative reasons of overriding public interest*"). For populations outside the Natura 2000 network, a case by case basis for permanent translocation would need to be made, based on the importance of the population, the value of the habitat within the population, and the likely stress caused by the translocation. In exceptional circumstances, in the unlikely event of such actions being permitted, added value could be achieved by carrying out the translocation via "short term breeding", a means of encysting fish with glochidia in order to translocate many thousands of juvenile mussels in addition to the adults (Moorkens 2015). Likely sustainable juvenile habitat would need to be identified in order to gain value from the short term breeding efforts.

6.2.6. Movement of mussels within a river from areas of chronically deteriorating catchment or river conditions

This translocation reason has been considered in various catchments, based on residual mussels in declining populations often being restricted to very poor silted habitat where adults are in danger of death and juvenile mussels could not possibly survive. These mussels are classed as "functionally extinct", and will be the last of the population in question without urgent intervention. The location of these mussels in the worst possible habitats, examples include the remaining mussels found in the Clun River, Shropshire, and those of the Cloon River, County Clare, Ireland. From river studies (refer to **Table 3, Annex 2**) where cleaner stable habitat has been identified in other parts of the river or sub-catchment, consideration should be given to moving mussels from degraded stretches. Losing mussel distribution would be the inevitable outcome of moving them from the degraded stretch. However, a balance is needed between the risks of moving stressed mussels or leaving them in-situ without addressing the causes of decline. Whilst improving water quality and catchment land use is a long-term commitment, this approach would ensure that genetic material is available to restock the river in the future.

Where upstream habitat has been identified to relocate adult mussels, a much safer approach would be to use the older mussels in short term breeding (Moorkens 2015), and to release the captive bred juveniles into a range of different areas, such that some survival may occur.

6.2.7. Movement of mussels within a river from reaches with no host fish to places with better host fish populations

This would be a relevant translocation where acidification has occurred, usually in upstream reaches, and host fish have recovered or persist in less acidified areas. Migration barriers may also isolate fish hosts from mussels. This situation is likely to occur very rarely outside Scandinavia, and losing mussel distribution would be the inevitable outcome of moving them from the degraded stretch. Far more important would be to address the issue of the barriers, so that appropriate fish hosts are restored, or to deal with the source of the acidity where that is the problem. As in other situations, instead of moving small numbers of adult mussels into unknown potential habitat, releasing captive bred juveniles or encysting resident fish would allow nature to find the most appropriate habitat for a new generation of mussels.

6.2.8. Movement of mussels within a river to areas of rehabilitated habitat where prior negative effects have been removed in conservation projects

This receptor-driven conservation action is likely to be populated best by large numbers of juvenile mussels, or by encysting native host fish. It is important to consider that all new populations of *Margaritifera* began with the release of juvenile mussels from encysted fish.

6.2.9. Movement of mussels within a river as a conservation action to move mussels upstream that have been washed down to estuarine habitats or to the lowest point of rivers beyond which survival is unlikely

This translocation action needs very careful thought, particularly as to whether adult mussels may be assisting the population by encysting fish that are moving upstream, thus providing a new generation for upstream habitats. An understanding of the dynamics of host fish movement and reproduction is important in this instance. Where mussels are perilously close to being washed into the sea or a river of very different chemistry or flow dynamics, movement upstream can be valid, but once again gaining the added value of short term breeding of juveniles or of host fish encystment (depending on the spread of potential juvenile habitat) would reduce the risk of a bad outcome compared to moving adult mussels alone.

6.2.10. Movement of mussels within a river to aggregate widely dispersed mussels

The case for aggregation seems obvious where widely dispersed single mussels are showing no signs of gamete production. It is very important to understand whether the lack of sperm / egg / glochidial brooding is chronic or intermittent, as studies have shown that stressed mussels will put resources into survival at the expense of gametogenesis following stress events, but will return to fecundity following recovery.

Bauer (1987) demonstrated that *Margaritifera* remain fecund throughout their life although there was evidence of individuals becoming hermaphrodite when isolated from other mussels. In a recent study, Hastie *et al.* (2011, extract from Iain Sime) looked into whether very low density pearl mussel populations may be unable to reproduce or recruit. By examining a range of pearl mussel populations across Scotland, at different densities, they concluded that mussels can reproduce (spawn/recruit) at very low densities in Scottish rivers. During the study it "was not possible to determine absolute critical minimum threshold mussel densities for successful spawning and recruitment processes for this species, since numerous physical and biological factors may be involved and each site is unique. Nevertheless, general trends were apparent and it was possible to construct simple probability curves for spawning and recruitment of *M. margaritifera* in Scottish rivers. Based on these, crude minimum density thresholds were determined for successful spawning and recruitment". One of the outcomes from their study was that mussels appear to be able to spawn at lower densities than those associated with successful recruitment. For example, 95% probability of spawning occurs at c. 0.03 mussels.m^{-2}, whereas 95% probability of successful recruitment occurs at c. 1.0 mussels.m^{-2} (This paragraph summary from a confidential report provided by Iain Sime, SNH).

At present, there is no evidence to indicate that aggregation to facilitate fertilization is likely to be either necessary or successful. On the contrary, there is evidence that low density older mussels can still produce glochidia, and therefore a spread of mussels may increase the chances of glochidial encystment on fish by producing glochidia over a wider area. Given that the reasons for a dwindling mussel population are most often chronic problems, due to poor water quality (nutrients and suspended solids), it is considered that the risks of bad outcomes of the act of translocation, and the reduction in the spread of risk load that would be ongoing following the aggregation (i.e. more "eggs in one basket"), particularly in small populations, would result in a higher overall risk to the remaining mussels than the likely benefits of aggregation. In declining populations, potential habitat that can sustain juvenile mussels through to maturity can be very limited, so of key importance is the protection of the widest possible distribution of mussels to promote glochidial encystment, to increase the chances of juvenile mussels dropping off in suitable habitat. This distribution becomes even more important as catchment management improvements result in an increase in the area of habitat that has recovered to suitability, but may no longer be occupied by mussels.

An exception for aggregation could be considered for mussels that have been washed into estuarine or otherwise totally unsuitable habitat, such as those washed into deep pools far downstream of the remainder of the population, but enough information on the structure of the fish population should be collected to ensure that these mussels are not located in areas where young fish congregate, where they may be playing an important role in glochidial encystment. Aggregation, if considered, should only be for a sample of singleton outliers, not every mussel such that it changes the overall current distribution range of the population. Under no circumstances should mussels be moved or aggregated in important areas of mussel distribution, no matter how depleted the population is. Key habitat areas should be supplemented with captive bred juveniles, or dosed with newly excysted juveniles or with encysted fish. The locations of adult mussels (even if widely dispersed) within habitat areas that are closest to sustainable condition are evidence of locations where mussels have survived, and are of great assistance to management and monitoring of both captive breeding and catchment management actions. This evidence would be lost if mussels were deliberately moved, and would increase the risk to the population. This concurs with Cosgrove & Hastie (2001) that such sites, even if currently suffering recruitment problems, should be maintained to allow for improvement over time, and with the Scottish translocation protocol 5 “do not remove organisms from a donor site if it will place that population at risk”.

6.3. From the above, it is clear that translocation is indeed a “*last resort*” tactic (Cosgrove & Hastie, 2001). Where mussels are needed to be translocated for captive breeding, they should be chosen from sites that will cause the least risk to the best areas, and where translocation between sites in the wild is being considered, the choice of donor and receptor sites should be very carefully assessed and documented both before, during and after translocation under a long-term monitoring scheme.

Information needed to inform decision-making

6.4. Current mussel and host information

Information on the current distribution of mussels in the catchment is essential, including all previous documented and anecdotal information on mussel distribution and population size. This is likely to already be available for most English rivers. In addition to adult mussel distribution, the distribution and abundance of juvenile and young mussels should be documented, and some demographic information should also be accumulated, providing some indication of when the population is likely to have last sustainably recruited young. This is important in understanding the likely timing and causes of population decline, and whether some areas of the river are closer to sustainable condition than others. Information should also be gathered on the host fish distribution in the river, including an assessment of encystment levels. Local anglers and fish scientists may already have good information on important areas of the river where young salmonids rest at times of glochidial release and juvenile drop off.

With enough population information, the wider conservation strategy for the population can be developed. Where this includes the consideration of translocation, it would be driven by the identification of mussel individuals that are unlikely to be making a contribution to the future of the population through extreme isolation, or through being washed downstream into very unsuitable habitat. Where the fish studies concur that these mussel individuals are not contributing to the population, and are not in suitable habitat, the main challenge then comes from the choice of receptor site.

6.5. Potential receptor site information

In some rivers, where all mussels have been documented as living in unsuitable habitat, receptor sites need to be considered from areas of the river that mussels no longer occur in. These receptor sites must be assessed by:

1) historical records of areas formerly occupied by mussels, where the habitat may have deteriorated but is now restored;

2) the flow regime must be suitable, providing hydrological and hydraulic conditions that encourage stable river bed habitats; and

3) the geomorphological conditions must be suitable, or have the ability to be made suitable.

The protocol for the surveys and assessments required to choose receptor sites is therefore very much dependent on the information available and the outcome of field studies and desk top investigations for potential translocation receptor sites.

The easiest way to quickly identify receptor sites is to find places where mussels are already living. These are sites that could be most safely augmented with other mussels. However, catchment changes may have changed the quality of some sites, such that they are no longer suitable for juvenile survival, and in these cases the presence of adults can be misleading. Moving mussels out of a donor site to augment a currently occupied site leads to a reduction in the distribution of mussels and possibly the range of mussels in that river, which may be a conservation disadvantage. Where consideration is given to receptor sites that do not currently host mussels, careful consideration needs to be given as to why there are no mussels there. Are their clear factors why mussels may have been lost from there in the past, but those causal factors have been rectified for both adult and juvenile mussels?

The first places to consider are the locations of sections of river that had historical records for mussels. The next choice would be sections of river with no historical mussel records but with potentially suitable flow conditions. This requires a review of the flow/hydraulic regime, resulting in a desk top assessment of potential adult and juvenile habitat locations. In populations where there are still significant numbers of mussels, where there is good distributional data, and where areas of most recent recruitment are known, this information provides a quicker means of identifying areas to be considered as potential receptor sites. Validation can then be carried out through studies of the physical environment. The use of flow velocity meters and redox potential meters are valuable in the field assessment.

The most difficult assessment is to determine receptor sites with sustainable flow conditions. The flow/hydraulic regime should identify the stretches of the river as potential receptor sites with permanent low flow conditions no slower than 0.25 ms^{-1} and high flow conditions not so high that they scour the river bed (Moorkens & Killeen, 2014). The presence of natural river bank conditions that allow flooding at depths higher than the average summer flood levels is indicative of suitable habitat. The desk top study should use GIS (gradient and land use datasets) and aerial photography to locate more natural stretches of the river with potentially suitable sections for further field investigation.

The field assessments should check the flow and morphological conditions at a smaller scale (metre square level), and assess the wider geomorphological conditions (river bank and landscape). The flow and geomorphology interact together, the flow affects the river bed substrate patterns, and the geomorphology determines flow velocities. Thus field studies should concentrate on looking for places with suitable stable bed material present in flow conditions where low flows will not lead to fine sediment infiltration, and high flows will not lead to scouring. For the latter, a functional flood plain provides the best protection. A positive assessment would be where river bank heights do not exceed the average summer flood level, so that during high flows water will spill onto the bank and dissipate energy, rather than remaining within the river and scouring the bed, resulting in loss of juveniles and in some cases lifting of adult mussels.

If sufficient information is known on the flow / hydraulic regime, and if the desk top study indicates that there is sufficient potential for sustainable adult and juvenile habitat, the following protocol for field study can be recommended:

1) Use the desk top study to identify upstream and downstream limits for field studies.

2) A field study should be undertaken in two parts. Firstly, a winter high flow bank walkover should be undertaken to ensure the identified stretches do not have high flow constraints – highly drained and dirty inputs and / or chronic suspended solids issues can be clearly identified in these conditions, as can over deepened or bedrock restricted areas leading to excessively high flows. Caution should be taken as high flowing rivers are dangerous and a safe distance should be kept away from the water, which should not be entered during high flows.

3) The second field study should be undertaken during summer low flows, and an assessment should be made for river bed habitat suitability and quality, river bed habitat condition, adult mussel numbers present, near-bed velocity, and redox potential. Suitable receptor sites should be mapped carefully and photographed.

4) A hydrological and geomorphological risk assessment of the local sub-catchments supporting the proposed translocation sites should then be undertaken to assess the resilience of the local catchment area in its role to protect against sediment and nutrient pollution, and against the exacerbation of drought conditions (particularly through artificial drainage of the upper mini-catchments), and its ability to protect the mussel population through appropriate detritus food production and delivery (sufficient connectivity of undrained land delivering positive juvenile mussel nourishment), and, where appropriate, the replenishment of stone of favourable clast sizes. This study is not constrained by season.

Table 3 summarises how field studies can be assessed. It must be understood that if all investigations at a site gave positive results, it is likely that a good population of *Margaritifera* would be likely to occur there already. However, the balance of positive and negative results provide the best indication not only of which sites are likely to result in success, but also what sort of ongoing conservation management might best improve the location for sustainable juvenile survival over time.

Where a number of different potential receptor sites have been identified by the desk study, comparing the assessments of the parameters above should identify which sites are more likely to result in success, and which would be high risk in the short and long term.

Table 3: Field assessments in potential translocation receptor sites

	Aspect	Assessment	Positive	Negative	Potential to improve
1	Mussels	Presence or absence	Presence	Absence	Not applicable
2	Mussels	Old records	Yes	No	Not applicable
3	Habitat condition	Redox potential	Decline in redox potential consistently <25% at 5cm	Decline in redox potential consistently or intermittently >25% at 5cm	Catchment management improvements - drainage reversal and/or silt / nutrient reduction can lead to improvements
4	Habitat condition	Filamentous algal growth	<5% cover and sparse, never luxuriant	>5% cover, persistent in low flows or episodic luxurious cover	Catchment management improvements - drainage reversal and/or silt / nutrient reduction can lead to improvements
5	Habitat condition	Macrophyte growth	<5% cover and sparse, never luxuriant	>5% cover, persistent. Combination of fine sediment and nutrient recycling favours rooted macrophytes	Catchment management improvements - drainage reversal and/or silt / nutrient reduction can lead to improvements
6	Flow velocity	Near bed velocity during low flow conditions	Near bed velocity at least 0.25 ms^{-1} in low flow conditions	Near bed velocity less than 0.25 ms^{-1} in low flow conditions	Catchment management improvements - drainage reversal and other suitable "slow the flow" techniques may assist sustainable low flow levels
7	Flow velocity	Check for turbidity and evidence of dirty outfall inputs	Clear water and no evidence of dirty outfalls entering river	High turbidity, suspended solids and dirty outfall inputs evident	Follow up and remove pollution sources, remove direct drainage / outfall into river, support integrated wetland buffers
8	Flow velocity	Visual check for velocity and flooding	Velocity is fast but not erosive, water floods onto natural flood plain	Water is concentrated within river at scouring velocities, or floods onto poorly managed muddy land	Over-deepened or reinforced high banks are unlikely to be rehabilitated without further damage to river. Protection of flood plain from over-grazing would keep flooded water clean
9	Geomorphology	Visual check for river bed substrate composition	Suitable stable substrate mix with variety of clast size, including gravels. Substrate black in colour	Unsuitable substrate mix – exposed bedrock or very evenly sorted bed material, or larger clasts but no gravels, or gravels and other clasts brightly coloured (i.e. unstable, regularly moved)	Exposed bedrock could not be made suitable. Where substrate is unstable due to historical removal of boulders, the placement of stabilizing boulders may improve habitat conditions
10	Geomorphology	Visual check for river bank height, natural	River not over-deepened or over-	River over-deepened (leading to excessive high flow velocities) or	Natural rock obstructions or long term damage is not easily reversed, and such

	Aspect	Assessment	Positive	Negative	Potential to improve
		rock barriers	widened, bank height not greater than average summer high flow levels, no rock constrictions	over-widened (leading to insufficient low flow velocities) or banks constrained by rock formations (leading to gorge conditions with excessive high flows)	areas should be avoided
11	Local catchment influences	Drainage levels in upper river catchment and surrounding mini-catchments	Low levels of drainage with extensive grazing or natural habitats	High levels of artificial drainage for agriculture or forestry, agriculture well developed	Reversal or mitigation of artificial drainage would improve conditions
12	Local catchment influences	Land use in upper river catchment and surrounding mini-catchments	Land use not intensive, no coniferous plantation, no arable, silage or high density animal stocking	Land use intensive, coniferous plantation, or arable, silage or high density animal stocking	Restoration of continuous cover forestry or low intensive agriculture would improve river conditions over time
13	Local catchment influences	Ability to provide favourable detritus and water contribution to mussel habitats	Wet conditions with sedge / rush / moss species close to the river, overland or through flow of detritus rich water	Dry conditions with poor connectivity for overland or through flow. Conditions not suitable for juvenile food production	Cutting off artificial drains to create a wetland close to the river would improve juvenile food production over time. Natural aquatic zones should not be cut off, particularly steep tributaries that provide fresh sources of gravel and other rock to the river

Final considerations

6.6. The translocation of adult mussels should be treated as a last resort action, where donor catchment level improvements are unlikely to return *Margaritifera* habitat into a condition that is conducive to juvenile survival within the lifetime of the remaining population. The direct movement of adult mussels has been demonstrated to be a high risk activity in many instances, thus interactions that increase the number of mussels with a new generation of juveniles and thus lower the risk of translocation are more desirable than moving adult mussels alone. The method of gaining the added value of a new generation of juveniles, and thus more individuals to trial in different receptor sites, depends on the condition of the population:

- Where the mussel habitat has been restored over a wide area, bankside encystment would provide the resource for potentially high numbers of juveniles to settle and could increase population numbers relatively quickly (Altmueller & Dettmer, 2006).
- Where good mussel habitat has been restored in a small number of areas, or limited good habitat remains in the wild, short term breeding can be used to produce large numbers of freshly excysted juvenile mussels to be placed in the best habitats (Moorkens 2015).
- Where the river is slowly recovering but not yet to a stage to support young juvenile mussels, longer term captive breeding can produce a new generation of young mussels to a stage where they no longer need to fully bury in the river bed substrate. These mussels should be used to supplement the remaining mussels in the best habitats where the native adult mussels remain extant.
- In very poor populations where the remaining mussels have low fecundity and adult mussels may have washed into very poor habitat, adult translocation should be considered, but with such a limited resource, the choice of translocation site needs very careful consideration.

6.7. While the recommendations in this document are quite onerous, the risk to the population of poor translocation choices is further damage. The reward for choosing sites and undertaking translocations wisely could be saving a population of a critically endangered species from extinction, and that would be a wonderfully rewarding outcome.

7. A protocol for the translocation of mussels and monitoring in England

Legal requirements, licensing

7.1. Based on the findings of this review a protocol for the translocation and monitoring processes has been developed to inform cases where a translocation has been assessed and documented as being suitable to progress.

The protocol does not replace the need for specific advice from Natural England and mussel experts. These should be contacted to discuss the specifics of your project.

As with the earlier stages of the assessment, due attention must be paid to all legislation and licensing requirements (see **Section 2**), and formalise a license for the exact translocation donor areas, receptor areas and numbers of mussels involved.

For development activities, this should include reference to the standing advice produced by Natural England, the Environment Agency and Defra. Further details can be found at: **https://www.gov.uk/guidance/freshwater-pearl-mussel-surveys-and-mitigation-for-development-projects**

Timing

7.2. Adult translocation and monitoring is undertaken outside the brooding season, during spring or autumn, in a period of relatively low flow and average air and water temperatures. The best time to carry out a mussel translocation would be from April through to late-June. Before this time in winter/early spring the mussels are likely to have a lower metabolic rate and may not respond well to disturbance. From late June to the end of August the mussel glochidia will be developing and disturbance at this time is likely to have a negative impact on the mussels, to such a point where the females may abort undeveloped glochidia. Timing of glochidial release varies between populations, but in England it occurs between late August and into the first week of September. There is another window of opportunity until mid-October, but the mussels must have time to settle before temperatures decrease and flows increase.

Translocation calendar:

J	F	M	A	M	J	J	A	S	O	N	D
No disturbance / movement			No seasonal constraints			Seasonal constraints		No seasonal constraints		No disturbance / movement	

Key:

Orange	Translocation not possible
Green	Translocation possible
Yellow	Translocation restrictions *

* Seek advice from conservation agencies

7.3. To plan the right timing for the translocation, ensure:

- The translocation is carried out only when the river is relatively low and the turbidity at its lowest.
- Water temperature is above 8^{o}c at the donor and receptor sites. At lower temperatures the work should not be attempted.
- If it is not possible to have full visibility at the receptor site, then the work should not be attempted.
- An accurate weather forecast is essential as the work should be carried out when there are clear skies and no heavy cloud cover.
- There should be no forecast for rain on the day of translocation or the subsequent 3 days.
- If the river flow increases before the mussels are settled, then they are very likely to be washed out.
- Where there is more than one translocation site, only complete multiple translocations if they are very close to one another and mussels will not undergo undue stress from delays, otherwise plan for multiple days.
- The translocation exercise should start as soon as there is sufficiently good daylight to allow for a full working day.

Preparation for the translocation day

7.4. Careful preparation is important to ensure that there are no delays that could cause unnecessary stress to the mussels, and that there is sufficient daylight to complete the translocation process.

- Ensure all licenses and permissions have been obtained.
- Ensure you have enough adequately trained and briefed personnel free to carry out the translocation. At least 2 people and preferably 3 should carry out the work and should all be available for the whole day(s).
- Check that the weather forecast and river conditions are suitable the day before, and sufficient for the translocation day and the subsequent 3 days.
- Visit the translocation site to ensure flows and turbidity levels are low.
- Make sure all of the equipment has been gathered together and is ready to load into the vehicle.
- Make sure the vehicle has sufficient fuel for the day before collecting the mussels.

Equipment

7.5. The following is a check-list of equipment needed for the translocation process.

Collection, handling and transportation:

- ☐ Net bags – these are used for collecting and transporting mussels. Bags approximately 40cm x 40cm and those made from low-cost net curtain material are ideal.
- ☐ Vernier callipers – for measuring the mussels
- ☐ Thermometer to measure water temperature

- ☐ Cool boxes to transport mussels
- ☐ Buckets (10 litre) to collect river water to transfer to cool boxes, and to transfer mussels from the river. Spare full bucket of water (sealed), in case of emergency!
- ☐ Ice packs or frozen river water in bottles to keep water cool in hot weather
- ☐ Old towels to be placed in the water in the base of the cool box to cushion mussels from bumpy conditions. The towels need to be clean (i.e. free of detergent) and should be washed several times before use.
- ☐ Aerator kit with its own battery pack and a long enough lead to sit on the bottom of the cool boxes or transport containers
- ☐ Dissolved oxygen probe to monitor DO levels (to help adjust the aeration kit)
- ☐ Bathyscope for viewing the river bed
- ☐ Chest waders/dry suit
- ☐ Life jackets

Replacement of mussels at receptor sites:

- ☐ GPS to relocate receptor site
- ☐ Tent pegs with streamers (such as orange nylon string) or capped rods to mark the bank locations
- ☐ Tape measure – used to measure distance of receptor site from the bank or other bankside features
- ☐ Trowel for assisting placement of mussels at the receptor site
- ☐ Additional gravels
- ☐ Underwater camera
- ☐ Waterproof paper and clipboard /waterproof electronic tablet
- ☐ Kitchen roll to dry mussels for marking
- ☐ Tags and glue or permanent water resistant pen for marking mussels for re-identification
- ☐ Bathyscope for viewing the river bed
- ☐ Waders/dry suit – to ensure that the mussels can be placed in their receptor habitat with ease, the person carrying out the operation should wear (neoprene) chest waders or a dry suit. Do not attempt this in wellingtons or thigh waders.
- ☐ Life jackets – when kneeling on the riverbed and digging into the substrate through the water column it is very likely that the inflation canister will fire. It may be necessary to authorise an exemption for the person carrying out the mussel replacement.
- ☐ Mask and snorkel – these are helpful for hands-free work when holding the bathyscope and placing mussels might be cumbersome.

Collection, handling and transportation

7.6. The preliminary investigations will have determined the locations of the donor mussels and how many are going to be moved. The numbers to be translocated will be agreed and specified in the Wildlife Licence from Natural England.

- At the donor site the mussels are likely to be in small or single numbers spread over a relatively wide area, in which case it is likely to take some time to collect them all.
- It is advisable to have two people working together, one to locate the mussels with a bathyscope and the other to carry them once collected. The mussels should be removed from their substrate and gently placed into a net bag, and not thrown or dropped on top of each other. Emersion should be kept to a minimum and the bag of mussels should be kept within the water during the process to avoid temperature stress. Do not attempt to overfill the bag or collect too many at once.
- The key to successful transportation is to provide the mussels with conditions in which stress will be kept to a minimum.
- Do not attempt to move mussels to or from multiple translocation sites on the same occasion unless located very close together. If they are separated by excessive distance, and / or accessibility is difficult, or there are delays at the first site, more than one translocation trip is needed to give the mussels the best chance to have a stress-free journey.
- The methods used to hold the mussels during transportation depend entirely on the distance being travelled and the ambient temperature on the day:
    - If the distance to be travelled is less than 20 km and less than 30 minutes driving time then the mussels may be placed in a cool box (or large buckets, or large tanks) on a cushion of towels wetted with river water on top of 2 or 3 cool packs (if needed). Towels should only be placed underneath and around the mussels to provide protection and not over the mussels. Do not overcrowd the boxes (20 mussels maximum) and do not under any circumstances close down or seal the lid.
    - If travel times or distances are greater, or ambient temperature is >20^{o}C then the mussels should be transported in cold boxes (or large buckets, or large tanks) filled with river water. Again the box should be cushioned with towels and the mussels placed in net bags (containing 10 mussels each) to prevent too much movement during transport. If the oxygen in the water is likely to become depleted then battery powered aerators should also be fixed in the boxes. Do not seal down the lid.
- Drive straight to the translocation site.
- Upon arrival at the receptor site, take water temperature readings from the transport containers holding the mussels and river. Begin gradually adding river water to the container to help equilibrate the temperature.

Preparations and checking equipment on site (River Esk, N. Yorkshire) © Hirst, S.; Cool box for transporting mussels with aerator kit attached © Hirst, S.

Transferring mussels to net bags for transportation (River Esk, N. Yorkshire); Mussels placed in net bags within cool box prior to transportation © Hirst, S.

Packing cool box with towels around mussels and aerator, River Esk (N. Yorkshire) © Hirst, S.

Marking mussels:

7.7. In order to assist with relocating translocated mussels and facilitating identification of individuals on follow-up surveys, it is recommended that mussels are marked, this is particularly important if there are already mussels in the receptor area [3]. On removing the mussels from their native habitat, they should be dried in patches using paper towelling (do not use solvents such as alcohol or acetone), and labelled using one of the following methods:

- **DymoTM tape or small vinyl tags** (e.g. Hallprint) with unique numbers attached with/embedded in superglue or epoxy resin. This has been successfully used in several mussel translocations although some tags do become detached or wear and become indecipherable within a short number of years. The procedure does take time, only a few should be dried at any one time and the adhesive also requires time to dry, all of which places stress on the mussels.
- **Engraving tool** – this does not require the mussels to be dried so emersion is kept to a minimum. However, there have been reports that engraving through the shell periostracum may accelerate erosion of the shell.
- **Permanent gel or "gold paint" pen** (e.g. Pilot Super Colour paint). This method has been used in Germany but again requires thorough drying of the shell both before and after application of the number. Additional dots of pen marks should be made on both valves close to each mussel's siphon area, so that marked mussels can be seen without lifting them out of the substrate. We have no information on how long the paint remains before wearing off.
- **PIT tags –** passive integrated transponder PIT tags are small, inert microchips with an electromagnetic coil encapsulated in glass and with a unique code. They are cheap and easy-to-deploy devices used widely as a method of increasing recapture rates and for long-

[3] Where a large number of mussels are to be translocated, marking or tagging all mussels will be time consuming and may not be necessary. A sub-sample of mussels should be selected and marked to aid post-translocation monitoring.

term monitoring, and are increasingly being used to monitor translocated freshwater mussels (e.g. Kurth *et al.* 2007, Wilson *et al.* 2011). Marking individuals with tags glued onto the shell with epoxy resin has been used in the Ballinderry River in Northern Ireland where they have been shown to be effective in increasing the rate of recovery, in the Inverpolly SAC in Scotland and in some American sites for other unionid species. However, Wilson *et al.* (2011) provided evidence that marking individuals with PIT tags significantly decreased their burrowing rate, although this was combined with the detrimental impacts of handling.

Small vinyl tag on mussels at receptor site on River Kent Cumbria (England) © Measures, G.

Placement of mussels in the receptor site

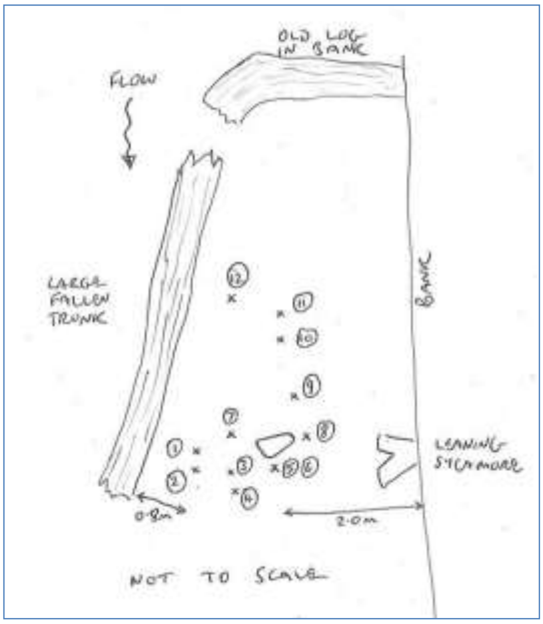
7.8. Mussels should be individually placed in pre-selected areas in groups appropriate to the suitability and capacity of the receptor location. Other mussels in the vicinity may provide information on suitable locations where to place the mussels.

- Care must be taken to ensure that mussels are placed in stable, un-compacted substrate, buried appropriately anterior end down with siphons facing the flow. Do not force the mussels into the substrate, use the trowel to open up a space in the gravels.
- Bury the mussels to at least half of their shell length. The presence of a 'tide-mark' formed by algae or a diatom coating may indicate the depth to which they were buried at the donor site. However, if the donor mussels were stressed they have risen to an unnaturally high level in the substrate, and may need deeper burial in a faster receptor site. Even if mussels are correctly buried they may perform a "righting" response, and attempt to lift out of the substrate and rebury again.
- In less stable habitats, the placement of some larger clasts around the newly buried mussels may enhance the stability of the substrate.
- The mussels should be observed to check that they settle into natural siphon function (should be within one hour).
- Take GPS, fixed point references, sketch map and photographs of the site and underwater to assist in relocation of the exact site for monitoring purposes.
- Return to the site within the following 2 days to ensure mussels have not dug themselves out and have been washed into totally unsuitable habitat. There may have been some movement and repositioning so a further set of monitoring photographs should be taken.

A method for placing the mussels back into the river:

7.9. The following method to transfer and place mussels at the receptor site has been developed based on the findings of the review:

- Once at the receptor site, take temperature readings from the cool box and river. Begin gradually adding river water to the cool box to help equilibrate the temperature.
- Whilst this is being done, another licenced person should locate the site(s) for returning the mussels too.
- Continue to monitor temperature and dissolved oxygen and add river water to the cool box.
- Once the water temperature has reached equilibrium, the mussels should be placed in net bags (if not already done) (no more than 10 per bag) and immediately put them into the river whilst the next phase (precise location of receptor sites, marking mussels etc) is underway. Don't place the bags in standing, warm water but put them in flow (preferably in shade) and weigh down the bags if necessary.
- If marking the mussels, dry them and use super glue to apply plastic tags or use a gold marker pen to mark the mussels on the top to facilitate re-identification.
- Place the mussels in the river in the identified locations. If there is limited gravel available, use the trowel to dig a hole for the mussels to sit in. Additional gravels can be used if required. Ensure that the transfer is as quick and as smooth as possible to minimise any stress.
- Place markers on the riverbank to enable re-identification of the site.
- After 20 minutes, take notes on mussel location, position and visual health.



White stones used to re-identify mussel locations – River Torridge (Devon); Sketch map used to re-locate mussels – River Torridge (Devon) © Moser, I.

Follow-up monitoring

7.10. Given the acknowledged poor success rate of translocations (**Section 4**), it is very important that adequate monitoring is undertaken.

- Regular surveys should be conducted to determine initial survival, recruitment, and persistence through the range of environmental conditions at the site.
- Translocated mussels should be monitored after one month, six months, one year and then ideally at least annually for five more years (until 6th year post translocation). If the population becomes established, annual monitoring should be continued to determine long-term survivorship and recruitment.
- The mussels and habitat should be photographed, counted, checked for markers, and their habitat assessed for quality and condition, and ideally redox potential measurements taken.
- To determine if reproduction is occurring, consider surveys of the resident or migratory fish populations to determine presence of glochidia on gills.
- Juvenile searches should be carried out during the 6th monitoring round. The habitat area should be checked carefully for emerging juveniles and in a subset of the habitats a demographic excavation of approximately 50 x 50cm should be undertaken.
- Annual monitoring should be undertaken in good survey conditions during low flow summer / early autumn conditions.
- In cases of failure the causes should be identified and eliminated before further translocations are undertaken. As many mortalities as possible should be collected and tested.
- Document the relocation. The procedures and location of introductions should be made available to the conservation agencies and in the scientific literature (where appropriate). The following should be reported: names of those conducting the introduction, species (taxa) and numbers involved, source of the introduction sample, size distribution, date of introduction, and exact location of the receiving habitat.

Rescue of mussels

7.11. This section applies to rescues as defined in the defence provided in Section10 (3)(a)) of the Wildlife and Countryside Act 1981 (see **Appendix 3**). In this situation mussels which are stranded or have been washed up onto shoals are moved back into more permanent or to more favourable habitat close-by. This does not require the detailed studies described for translocations but the person carrying out the rescue can refer to the relevant sections above particularly for handling and placement, and also the screening tool to ensure that the mussels are replaced somewhere they have a chance of survival. However, these mussels may be moribund if they have been emersed for several days and will likely die anyway. Others are likely to be highly stressed and have poor muscular strength to bury and anchor in the substrate, in which case they must be located in very favourable habitat where the chances of being washed out soon after replacement are minimized. Some post-monitoring would be valuable as we have very little data on the success of this type of rescue.

Advice from specialist Natural England staff should be sought in situations where large in numbers of mussels are needing to be rescued. Ongoing monitoring will be to valuable in order to assess the success of this work in the longer term.

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Appendix 1. Case Studies

England

1.1 River Torridge

Following plans to modify an existing gauging station on the River Torridge at Great Torrington, Devon, four mussels living in the vicinity of the works were translocated a few hundred metres upstream. The mussels were marked with DymoTM and placed in suitable habitat near other resident mussels in August 2002. All 4 were still identifiable in July 2003 but by July 2004 the Environment Agency could no longer identify the individuals because no mussels with numbered markers could be found and the substrate within the quadrat had moved significantly. It was considered very likely that those mussels died due to drought conditions in summer 2004.

Source: Pers. comm. Mary-Rose Lane, Environment Agency

Reference: Michel Hughes Associates, 2002. Translocation of a population of the freshwater pearl mussel (*Margaritifera margaritifera* (L., 1758)): River Torridge, Great Torrington, Devon. Report by Michel Hughes Associates to the Environment Agency.

1.2 River Torridge

Mussels which had been held in captivity at the Freshwater Biological Association, Windermere and at the Mawddach hatchery in north Wales since 2007 were placed back at a site at Blinsham on the River Torridge in June 2014. Several had died by 04 August and their shells were recovered. Although the mussels may well have been moribund by the time they were relocated, they are likely to have been too stressed to have survived the repatriation.

Source: Killeen, I.J., 2015. An assessment of freshwater pearl mussel current and potential habitat in the River Mole, Devon. Report to the North Devon Biosphere.

1.3 River Kent – Dubbs Beck

In 2011/12 work was undertaken to remove silts and clean gravels from badly affected locations in the lower sections of the river immediately upstream of the remaining mussels. In May 2011, Natural England removed 36 mussels in the downstream sections and relocated them to suitable habitat 1km upstream. A second batch of 9 mussels were later removed in June 2012 whilst the restoration works were carried out. All mussels were tagged with Hallprint shellfish tags to help with re-finding the mussels.

Monitoring was undertaken initially every 6 months so as to able to relocate the mussels and checks were made to determine their overall health (i.e. how well they were filtering or showing signs of stress). The results showed that within 12 months of being relocated, 75% of the first batch of mussels and a 90% of the second batch were re-found. In subsequent years, mussel numbers declined with a 67% loss recorded in the first batch (24 of 36) and a 55% (5 of 9) in the second batch over a 5 year period. There were a number of flood and drought events recorded over this period that may be possible factors in the observed losses.

Source: Unpublished reports. Gavin Measures, Natural England

1.4 River Lune

Seven adult mussels which had been held in captivity at the Freshwater Biological Association, Windermere since February 2011 were returned to the River Lune at end of April 2014. These were then periodically checked but at the last check in late June 2014 four mussels had died and 3 were alive. No further checks have been carried out since.

Source: Pers. comm. Jana Kahl, Environment Agency

2. Wales

2.1 Afon Ddu, Gwynedd

In 1995 dredging of a small upland stream resulted in the near eradication of a previously unknown pearl mussel population. During a survey in July 1996, 342 living mussels were found in the impacted section, along with large numbers of dead shells and moribund individuals. Given the very poor substrate quality and low water depth, a decision was made to move the surviving mussels to a downstream section of the stream which had not been dredged (there was no suitable upstream habitat). By October 1996 the number of translocated mussels had dropped from 342 to 162 (53% loss). The remaining mussels were tagged with dymoTM tape and replaced in apparently suitable substrate. A further survey in July 1997 showed the die-off had continued and only 40 individuals had survived. By 2013 all of these translocated mussels had disappeared (Killeen personal observations).

Source: Killeen, I.J., Oliver, P.G. & Fowles, A.P., 1998. The loss of a Freshwater Pearl Mussel (*Margaritifera margaritifera*) population in NW Wales. In: Killeen, I.J., Seddon, M.B. & Holmes, A., 1998. Molluscan Conservation: a strategy for the 21st Century. Journal of Conchology Special Publication No. 2.

2.2 Afon Teifi, Ceridigion

In a survey in 1997 the 12 mussels found over a wide area of the Afon Teifi downstream of Llechryd Bridge were gathered up at the time and relocated in a run with good substrate under a tree on the north bank of the river c. 100m upstream of the bridge.

The translocation site was visited on 2 occasions in summer 2006 but no living individuals, dead shells or fragments were found.

Source: Killeen, I.J., 2007. A survey of Welsh rivers supporting populations of the freshwater pearl mussel *Margaritifera margaritifera* (L., 1758). CCW Contract Science No. 770

3. Scotland

Much of the work carried in Scotland up to 2012 was summarised, in a Species Action Framework (SAF) handbook (see **http://www.snh.gov.uk/docs/A1590814.pdf**).

3.1 Speyside, Deeside and Lochaber

Two intra-catchment transfers were undertaken with the Cairngorms National Park Authority in 2005 from the mainstem of two rivers in Speyside and Deeside into tributaries from which the species had become absent. In 2009 a SAF project comprised an inter-catchment transfer into a catchment in Lochaber from another donor population in a different catchment. A summary of the numbers of mussels originally moved, and the results of follow-up surveys are shown in the table below.

Table 1: Survey results for Cairngorms freshwater pearl mussel reintroduction

Region	Site code	Year of reintroduction	Mussels introduced (n)	Follow-up results	
				2010	2015
Speyside	Site 1a	2005	500*	59	31
Speyside	Site 1b	2005	250		
Speyside	Site 1c	2006	216*		
Deeside	Site 1	2005	100	20	5
Deeside	Site 2	2005	100		
Lochaber	Site A	2009	150	98	64
Lochaber	Site B	2009	50		

*216 mussels moved to site 1c during 2006 (from site 1a) due to habitat damage at Site 1a

It could not be concluded that the unfound mussels were dead, as they could have been buried or redistributed much further downstream (although the surveys tended to extend about 500m downstream from the reintroduction sites). Following the 2015 surveys, it was concluded that the Deeside reintroduction site was no longer suitable for pearl mussels. In the years subsequent to 2005, the reintroduction site changed in morphological character and became more dynamic with a substrate that was clearly more prone to turnover and erosion/deposition than it was when the mussels were moved.

Source: Pers. comm. Iain Sime, Scottish Natural Heritage

Hastie, L.C. 2007. Cairngorms Freshwater Pearl Mussel Reintroduction Project Phase II(B). Final Report. Commissioned by Cairngorms National Park Authority / Scottish Natural Heritage, Grantown-on-Spey / Inverness.

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3.2 Stac Burn

Part of a study in western Scotland involved moving 2 batches of 20 mussels (all tagged with dymoTM tape) from the Stac Burn to a location 30m up a tributary of the Stac Burn. The Stac Burn was c. 3m wide, generally 0.2-0.5m deep, and with a mixed substrate ranging from coarse sand to boulders, and flowing from a small loch. The tributary was similar in most respects except that there was no loch upstream, and, therefore, the hydrological regime was much less stable.

The results of the study gave a loss of 71% of the first batch of 20 mussels after a period of 14 months, and a 50% loss from the second batch after 8 months.

Source: Young, M.R. & Williams, J.C., 1983. Redistribution and local recolonization by the freshwater pearl mussel *Margaritifera margaritifera* (L.). Journal of Conchology, 31: 225-234.

3.3 River in west Sutherland (within river translocation)

Mitigation for a small hydro-electric scheme comprised moving 695 mussels away from the impact area of the proposed works. This was carried out on 2 occasions in 1999 and spring 2000. During monitoring in October 2000, over 60% of the marked mussels were re-found. In 2002 a further survey showed that over half (55%) of the translocated mussels were re-found three years after the original translocation exercise. It is not known if there has been any subsequent monitoring.

Source: Anon, 2006. Draft report for DTI New and Renewable Energy Programme. ETSU H/06/0057/00/REP (Unpublished).

3.4 River in Ross-shire (within river translocation)

A translocation was carried out on behalf of the North of Scotland Water Authority (now Scottish Water) to move mussels away from works for a waste water effluent pipe. In 1999 a total of 145 mussels were moved to 2 sites upstream and downstream of the works area. It is believed that a survey carried out soon after the translocation showed the mussels had survived, but there does not appear to be any further follow up.

Source: Pers. comm. Iain Sime, Scottish Natural Heritage

3.5 Inverpolly SAC (within river translocation)

In 2013 SNH carried out a small translocation of c. 30 mussels within two rivers in the Inverpolly SAC to determine if they would survive in reaches where pearl mussels had died previously (believed to be a result of toxins). The mussels were individually PIT tagged and moved to 3 locations within the same watercourses that the animals were resident. A survey in 2014 resulted in over 90% of the animals found alive.

Source: Pers. comm. Iain Sime, Scottish Natural Heritage

4. Ireland

4.1 River Nore

A total of 13 adult mussels which had been held in captivity at a hatchery c. 50km from the River Nore since February 2011 were returned to their native river in July 2014. After 1 month, only 6 individuals were recovered. No further checks have been carried out since.

Source: Moorkens, E.A., 2014. Report on assisted breeding of the Nore pearl mussel. Unpublished report for National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

4.2 River B, County Kerry

In September 2013, 51 mussels lying in the vicinity of bridge upgrading works were moved. After 8 months, 35 of the 51 were recovered.

Source: Pers. comm. NPWS, Department of Arts, Heritage & the Gaeltacht

4.3 River D, County Kerry

Thirty individuals were taken from the river, transported in tanks to a facility for sampling genetic material, marked and then returned to habitat close to the sites from which they were taken within the same 24 hour period (in September 2015). After 3 weeks 20 mussels were recovered.

Source: Moorkens pers. observations.

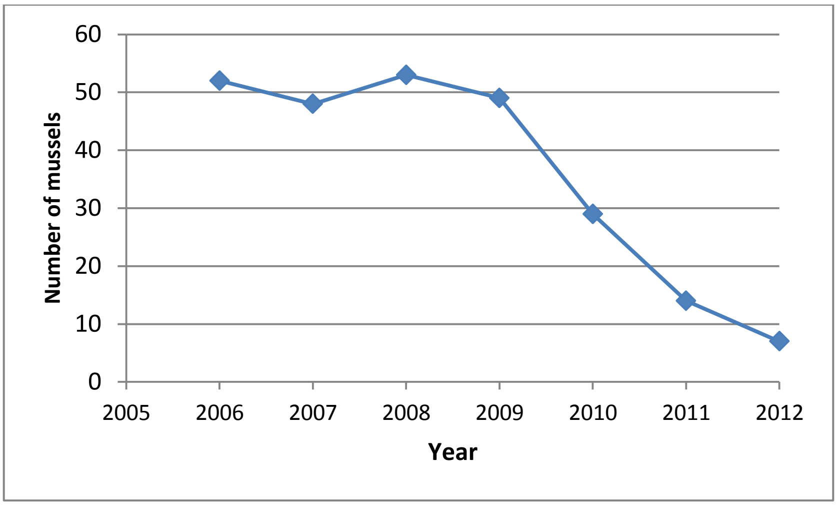
5. Germany (Bavaria)

5.1 River A

Mussels in a stream in Upper Palatinate which were being impacted by wastewater from a stone quarry were translocated in 2006 to a location 7.5 km upstream. The youngest mussels at that time were 60 years old, and the majority more than 80 years. The original site was moderately polluted with municipal sewage and from agriculture whereas the receptor site was located at the headwaters with forested catchment and clean water. A total of 52 (tagged) mussels were moved in 2006 and a further 10 moved in 2008.

The graph below shows the numbers of mussels recorded annually until 2012 when the remaining (7) were taken out and moved into another nearby watercourse in the same watershed with an existing mussel population. The number declined only slowly from 2006 to 2009 but thereafter the annual rate of loss increased considerably.

Figure 1: Annual survey results of translocated mussels: River A

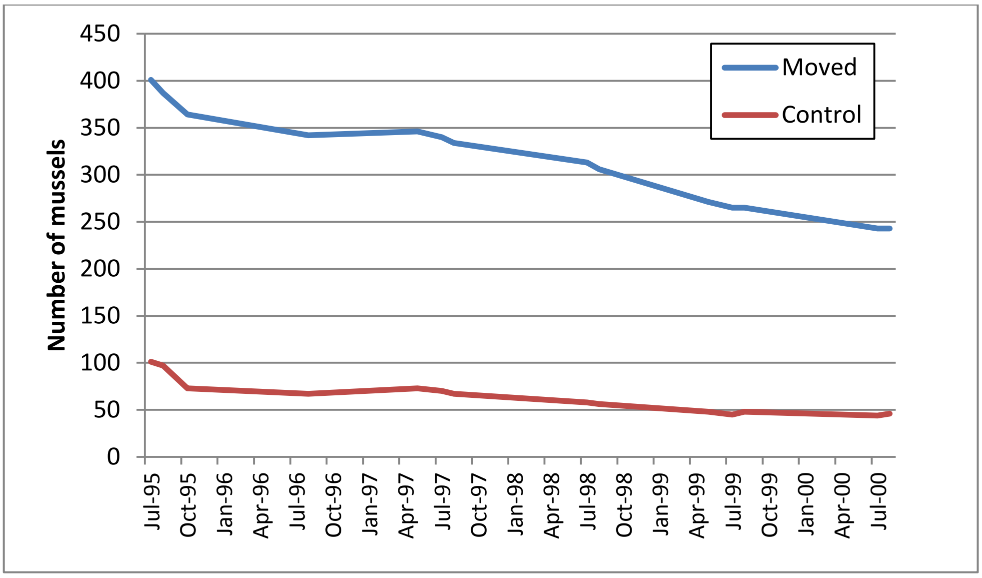


Source: Pers. comm. Christine Schmidt & Robert Vandré, Schmidt & Partner, Goldkronach.

5.2 River B

In 1995 a main road crossing the stream at the lower end of a stretch inhabited by *Margaritifera* was upgraded into a Motorway. In order to protect the mussels downstream of the motorway, the Nature Conservation Authority of the District Government of Upper Franconia required relocation of mussels and their monitoring for 5 years. In 1995 a total number of 4,894 mussels were moved from downstream of the road crossing into a river section with similar water chemistry 3 km upstream. The translocated mussels had an age of 17 to ca. 100 years, but most were 40 to 80 years old. A total of 400 translocated mussels were individually marked together with a control group of 100 already resident at the new site. The moved and marked mussels were older (mean age 63 years) than the control group (mean age 51 years). The graph below shows the numbers of translocated and resident mussels recorded from July 1995 to July 2000. Over the monitoring period, 39.4% of the translocated mussels were lost, compared to a loss of 54.4% of the unmoved mussels.

Figure 2: Survey results of translocated and resident mussels: River B



Source: Pers. comm. Christine Schmidt & Robert Vandré, Schmidt & Partner, Goldkronach.

5.3 River C

In September 2009 a total of 139 adult (and probably aged) mussels from a bankside depot in a section of the river with low flow velocity and a high proportion of fine sediments in the river substrate downstream a hydropower station were relocated about 13 km upstream into a more natural habitat (coarse sediment, high discharge).

No mussel monitoring was carried out in the following years until as part of a research project by Schmidt & Partner in 2014 with the objective to indicate the impacts of pulsed flows from the hydropower station the sites were again searched. At the original site downstream of the hydropower station about 40 old mussels were found, which had been missed in 2009. At the new translocation site upstream of the hydropower station only 6 mussels were recovered, although several hundred meters downstream were searched too.

Source: Pers. comm. Christine Schmidt & Robert Vandré, Schmidt & Partner, Goldkronach.

6. France

6.1 Brittany LIFE

During the conservation programme on Margaritifera margaritifera in the Armorican Massif (Brittany, France), aggregation of adult mussels was carried out in the hope of improving fertilization, and to facilitate easy glochidial collection for a captive breeding programme. This was carried out by moving mussels (around 10 individuals) from 5 populations within their same river or catchment over distances raging from a few meters to 1 km. This was carried out between 2012 and 2014 and it is understood that all mussels were still alive in autumn 2015.

Source: Pers. comm. Marie Capoulade, BRETAGNE VIVANTE-SEPNB

7. Finland

Restoration and restocking of unknown rivers in Finland was carried out between 1980 and 1995. Whilst there are no details or methodology or timescales documented, it was reported that mussels translocated to a different river had a much worse fate than if translocated within their own river of origin, but with no details or causal factors. An average of 10% mortality was recorded within in the same river, whereas there was 50% mortality between rivers.

Source: Valovirta, I. & Yrjänä, T., 1996. Effects of restoration of salmon rivers on the mussel Margaritifera margaritifera (L.) in Finland. In: Proceedings of the colloquium on conservation, management and restoration of habitats for invertebrates: enhancing biological diversity. Council of Europe T- PVS (96) 51, 38-48.

8. Sweden

The County Administrative Board of Norrbotten has carried out two translocations of freshwater pearl mussels, but none of them have yet been followed up. A further two translocation were carried out in the southern neighbouring county, Västerbotten, by the County Administrative Board of Västerbotten (not followed up) and one by the Skellefteå municipality (followed up).

8.1 River A (Norrbotten) – Translocation within the river

In 2012 an experiment was carried out to translocate 250 mussels (10% of the population) of a 10km length of river from the upstream 640 meters of the river, from the outlet of the small lake, to a location with apparently suitable habitat and good host fish population further downstream. The rationale for this work has not been provided. Initially 25 mussels were moved in September 2012. They placed 12 mussels in 3 crayfish cages (4 in each cage) filled with natural bottom substrate, and 13 mussels were placed around and in-between the cages. On the 26th of June 2013 all mussels were found in the cages and alive. A further 232 mussels were collected from the upper part of the river (only mussels larger than 50 mm in length) and were placed in three different locations that looked suitable: a deeper areas with larger stones, larger dead wood and stable bottom, under the riverbank and below shadowing trees. A follow up is planned for August 2016.

8.2 River B (Norrbotten) – Translocation between rivers within the same river system

In 2013 a survey of the river resulted in an estimate of 73 individuals within a 7 km river stretch. In October 2015, 483 mussels were taken from a tributary situated approximately 4.5 km upstream of the River B. The mussels where placed at two different locations that had previously been identified as having good numbers of host fish and suitable substrate. It is hoped that a first follow-up will take place in 2016.

8.3 River C (Västerbotten) – Reintroduction

The River C formerly had a good FPM population but during the timber floating period the river was drained when the water was diverted into a dug channel and most of the mussels where killed. In 2006 only three live individuals where found. Since 2009 the river was restored to its original course.

950 mussels (length from 40 – 130 mm) were taken from different catchment river 110 km to the north-west. They were placed in five different sites in River C, spread on a 600 m long stretch. The sites were chosen where there was suitable substrate, water depth and velocity. Fifty mussels at each site were measured and marked. There has been no follow-up and it is not known if or when it is planned.

8.4 River D (Västerbotten) – Reintroduction

The reason for the disappearance of the mussels is unknown. River restoration has been carried out and there are good numbers of host fish present. Mussels were taken from two different rivers, 550 mussels from one donor population (mean length 95 mm) and 150 mussels from a second donor population (mean length 93 mm). The mussels where placed at two different sites:

1) in one 50m long section, 300 mussels (only from donor 1) placed in three different areas.

2) in two 50m long sections, 400 mussels (250 from donor 1 and 150 from donor 2) placed evenly across the whole 50 meters.

At each site 100 mussels were marked. Five days after the mussels were placed in the water they were checked for survival and the survival was checked every year from 2008-2012 (see table below). No monitoring has been carried out since 2012.

Table 2: Annual survey results of reintroduced mussels: River D (Västerbotten)

Site1				Site 2			
Year	Live mussels	Dead	Overall % loss	Year	Live mussels	Dead	Overall % loss
2008	300	0	0	2008	400	0	0
2009	169	6	43.7	2009	342	2	14.5
2010	147	3	51	2010	310	6	22.5
2011	89	3	70.3	2011	220	66	45
2012	105	0	65	2012	241	9	39.8

The mussels at site 1 had moved 240m downstream in 2012. The bottom substrate had moved around during the years and was considered to be a bit unstable. Site 2 was judged to be much more stable with larger boulders. The losses between 2010 and 2011 were thought to have occurred due to bottom freezing.

8.5 River E

48 individuals were reintroduced in 2010. In 2012, 23 live mussels + one shell were found, 33 + one shell were found in 2013 and 26 individuals were found in 2014. No glochidia were found on local trout in 2011 and 2012.

Source: Pers. comm. Patrik Olofsson, County Administrative Board of Norrbotten, Luleå, Sweden and:

Reference: Återintroduktion av flodpärlmussla i Stor-Kvarnbäcken 2010. Lars Björkelid, County Administrative Board of Västerbotten. Project – Rinnande vatten i Kvarken.

9. Norway

A recently published report from Norway (in Norwegian) gives several examples of mussel translocations. A summary of the 3 rivers where there has been subsequent monitoring are given below.

9.1 River A

88 individuals were moved 1 km within the same river. After one year 83% (mean value) were re-found. The percentage of mussels re-found varied between the 6 sites from 53 – 100%.

9.2 River B

250 individuals were moved from another river within the same catchment, 2.5 km distance. After one year 63% (mean value) were found. The percentage of mussels re-found varied between the 5 sites from 52 - 80%.

9.3 River C

406 individuals were moved 100-350m upstream to a previously restored channel. After one year 46% (mean value) of the mussels were re-found. The percentage of mussels re-found varied between the 10 sites from 5 – 80%.

Source: Larssen BM, 2015. En oppsummering av tiltak for elvemusling i Norge iverksatt gjennom handlingsplanen eller tilskuddsordningen for prioriterte arter. NINA report 1208, pp 60. ISBN 978-82-426-2838-1

10. United States

Whilst there is very little published data on *Margaritifera* translocations in Europe, but there is more information on American unionid mussels. Several examples are given by Dunn *et al.* (2000) including translocation of *Cumberlandia monodonta*, a species not dissimilar to *Margaritifera*. A 2015 survey in the Mississippi involved the PIT tagging and relocation of 10 *Cumberlandia*. However, after 3 weeks, only 50% of the individuals could be re-found.

Appendix 2. Screening Tool

Screening tool to identify potential receptor/ translocation sites for the freshwater pearl mussel (*Margaritifera margaritifera*)

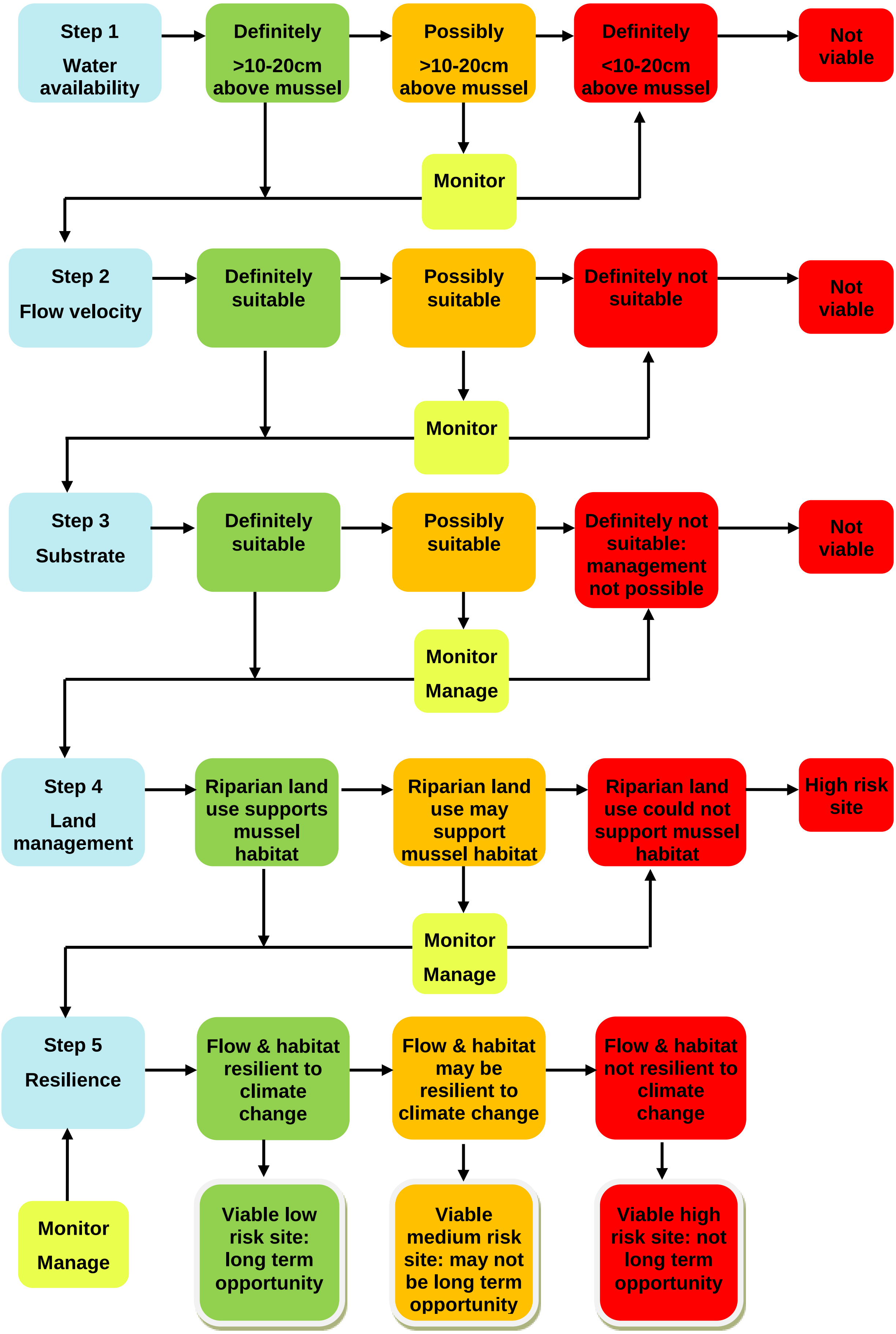
As part of the River Clun SAC Restoration Strategy (Atkins, 2012), a screening tool was produced to help the assessment of sites according to their potential to be receptor locations for freshwater pearl mussels as a management measure. The tool includes five sets of parameters that link to controls on mussel viability and are considered in a stepwise manner i.e. in order of importance with respect to their viability. Sites are required to meet each step or to require monitoring to confirm the potential to meet each step to avoid exclusion as locations that are not viable. The parameters are explained in the Table below. The stepwise pathway for application of the tool is summarised in the flow diagram below. The tool enables each potential receptor site to be classified according to one of three categories:

- **Red** not viable: not suitable for relocation, mitigation via management not possible;
- **Amber** possible future opportunity: management and/or monitoring required; and
- **Green** suitable relocation site without need for management or monitoring.

Table 1: Explanation of parameters included in the screening tool

Parameter	Rationale	Status
Water availability	Adult mussels require >10–20cm depth of water above the top of the mussel at all times of year.	**Site Fails Assessment**: reliable water depth is essential to survival. Mitigation via management is not possible.
Flow velocity	Adult mussels require a suitable flow velocity to ensure that the substrate in which the mussels bury is stable.	**Site Fails Assessment**: excessive flow velocity precludes anchoring; suitable flow is essential to survival. Mitigation via management is not possible.
Substrate / Geomorphology	Juvenile mussels require substrate that is aerated, stable, and free of fine sediments. Both adults and juveniles require substrate with an appropriate clast size composition and angularity.	**Management opportunity**: there may be potential for improvement to substrate e.g. via catchment management.
Land management	Adult and juvenile mussels require the adjacent land to be managed appropriately to minimise sediment inputs and maximise stability and habitat.	**Supports success**: good riparian land use reduces the risk of failure. Improved land use via management is possible.
Resilience	All potential receptor sites need to be resilient to climate change and able to provide appropriate habitat in the long term.	**Supports success**: a resilient site (e.g. robust flow and land use) reduces the risk of failure.

Flow chart: Assessment of potential pearl mussel receptor sites



Notes on parameters

1. Water availability - depth

Areas of very shallow water can get exposed in drought conditions and very deep areas can have lower flows and allow settling out of fine sediments. Ideal depth is around 30-40cm deep, can be deeper or shallower, but must always be wetted even in drought conditions [4].

2. Flow velocity

An adequate flow is one of the most important ecological requirements for pearl mussels and a key indicator when assessing potential recovery sites. Optimal flow velocity of 0.25-0.75ms-1 has been reported in Scottish rivers (Skinner *et al.,* 2003). Near-bed velocities over optimal mussel habitat of 0.27–0.31 m s−1 has been reported in Irish rivers at relatively low flows (Q85) (Moorkens and Killeen, 2014).

Low summer flow velocities can allow the formation of algal mats and reduce interstitial–water column mixing. Water flows/velocity in summer should therefore be sufficient so as not to induce low oxygen levels or heat stress, and be sufficient to reduce the sedimentation of fine particles and detritus, especially in areas where juveniles aggregate. In high flows substrate may become scoured and thus unstable.

3. Substrate / Geomorphology

Freshwater pearl mussels requires stable, mixed-size substrate within a permanently wetted (with adequate depth of water column above the top of mussels) channel which exhibits tolerable flow velocities throughout the year. Juvenile pearl mussel require adequate areas of sand-sized substrate in which to burrow and are even more susceptible to the effects of increased sediment load than adults. Adults and juveniles have broadly similar habitat preferences as defined above, but adults tend to occupy a wider range of physical conditions.

Substrate should be composed of particles of varying sizes. Require sand and fine gravels to bury into, particularly as juveniles. Fines/silt should be < 25%. Boulders and cobbles provide stability and protection from high flows.

Optimal habitat: significant deposits of stabilised, clean coarse patches of sand and gravel in amongst large stones or boulders [5]. Presence of moss on large substrate (e.g. Fontinalis) is an indicator of bed stability and good mussel habitat.

Unsuitable habitat: generally characterised by extreme flows, mobile, well-sorted sediments and/or unsuitable substrate types including ‘compacted’ beds due to siltation. Densely vegetated areas are unsuitable as these tend to trap silt and organic debris.

Where substrate is unstable due to historical removal of boulders, the placement of stabilizing boulders may improve habitat conditions.

4. Land management

[4] Surveys should be conducted following a period of sustained dry weather, at a time when there is likely to be maximum water stress (depth and flow velocity) and when the river bed is visible.

[5] In order to correctly identify optimal habitat, the typical stable gravel/cobble and boulder/cobble/gravel habitats need to be recognisable from unstable gravels or unsuitably uniform or concreted gravels. The more black and heterogeneous the substrate, the more suitable it is likely to be. This has been well described in Hastie et al., 2000; Skinner et al., 2003; ECS, 2015).

Adult and juvenile mussels require the adjacent land to be managed appropriately to minimise sediment and nutrient inputs to maximise habitat conditions. In addition to the physical in-channel habitat (see above), the following river corridor conditions should be considered:

- Riparian fencing, buffer strips, tree planting, sensitive coppicing and adjacent land use e.g. under agri-environment agreement or low intensive management etc.
- Woodland and shade: presence and shade from well-established bankside trees with good long term health/pro-active management.
- Woody debris: presence of woody debris habitat but not to such a degree that it can substantially alter flow patterns.
- Wastewater treatment: wastewater treatment facilities should be a material consideration in site assessment due to impacts on water quality.

5. Resilience

Evidence from the UK Climate Impacts Programme, shows that the climate in the UK over the coming century is likely to become warmer and wetter in winter and hotter and drier in summer. In addition, rainfall intensity will probably increase; there will be increased erosion in winter, resulting in more fine material and nutrients being washed into rivers. See:
http://publications.naturalengland.org.uk/publication/50005

Adaptation measures include; the expansion of riparian woodland to help moderate against temperature fluctuations and also act as a buffer between intensive agriculture and the river. Planting should promote a variety of tree species to adapt to water stress, losses due to storms and tree pathogens (e.g. *Phytophthora alni* and *Hymenoscyphus fraxinea* which present a threat to alder and ash).

Catchment management improvements such as drainage reversal, natural flood management and other suitable “slow the flow” techniques may assist sustainable low flow levels. The introduction of sustainable farming practices and water resource management should be promoted.

Appendix 3. Legislation (England)

Legal protection

The freshwater pearl mussel and it's habitat are fully protected by law in the UK. It is listed under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended) and is covered by the provisions of section 9 of the Act. Details of the legislation can be found at:
http://www.legislation.gov.uk/ukpga/1981/69/contents

Full legal protection under the Act makes it an offence to:

- intentionally or recklessly kill, injure take or disturb freshwater pearl mussels or
- to damage their habitat. 'Habitat' in this case can include any structure or place used for shelter or protection and
- to sell, or advertise for sale, freshwater pearl mussels or their 'pearls'.

The Act provides a defence against the above where the action is the 'incidental result 'of an otherwise lawful operation and could not reasonably have been avoided (s.10(3)(c)). See details below.

Offences under the Wildlife and Countryside Act can be punished by six months imprisonment and/or a level 5 fine (£5,000). Offences are summary only.

The freshwater pearl mussel is also listed under the European Habitats Directive 1992 (Annexes II and V) and is protected by the Conservation of Habitats and Species Regulations 2010 ("the Habitat Regulations"). Details of the legislation can be found at:
http://www.legislation.gov.uk/uksi/2010/490/pdfs/uksi_20100490_en.pdf

Use of the incidental result defence

This defence provides for the carrying out of lawful operations from which some harm to the species that would otherwise be an offence is caused as an incidental result that could not reasonably have been avoided. This therefore requires that attention is paid to the presence of freshwater pearl mussels and, as far as is reasonable, appropriate action is taken to safeguard the animals and the places they use for shelter and protection. Ultimately only a court can decide what is reasonable and to what extent adverse impacts might have been reasonably avoided in any set of circumstances and Natural England cannot provide legal advice.

Licensing

Wildlife licences are available from Natural England to allow activities that would otherwise be an offence, including:

- for scientific or educational purposes;
- for the purposes of ringing or marking;
- for conserving wild animals or introducing them into a particular area;
- preserving public health or public safety;
- preventing the spread of disease; and
- preventing serious damage to any form of property or to fisheries.

There are no licensing purposes that explicitly cover development activities or activities associated with the improvement or maintenance of land or waterways. For more information regarding species licensing visit our website at: **https://www.gov.uk/guidance/wildlife-licences**

Important note – separate approvals may also be required from the Environment Agency and, if a Site of Special Scientific Interest (SSSI) is affected, from Natural England. These should be secured before applying for a licence. An offence may be committed if you proceed without them.

Survey and monitoring licences

Monitoring of protected species such as freshwater pearl mussels that may cause disturbance (risk of injury to mussels and of interference with or destruction of their habitat) will require a Wildlife Licence. This includes any survey or monitoring method aimed at finding freshwater pearl mussels and involves handling them for counting or identification purposes (even if they are released nearby shortly afterwards), or for removal and containment.

A licence is not needed for habitat appraisal, passive viewing or general ecological survey purposes (where freshwater pearl mussels are not the specific target) provided that any protected species encountered are not disturbed.

A licence is needed where electro-fishing is carried out in the vicinity of freshwater pearl mussel beds. It is thought that electro-fishing is not harmful to mussels, although steps should be taken to ensure that, where possible, mussels will not be exposed to long periods of electro-fishing or excessive disturbance. Users of this licence should first check the distribution and density of mussels and get appropriate advice from specialist Environment Agency staff.

Licences to take freshwater mussels

Licences are not available to take freshwater pearl mussels in order to rescue individuals or move them out of the way of a development or activities associated with the improvement or maintenance of land or waterways. The removal of freshwater pearl mussels for translocation from a site is unlikely to be considered the 'incidental result' of other activities and so is not covered by the defence in legislation (see section above). If, despite all reasonable efforts, properly authorised development/activity will adversely impact on freshwater pearl mussels and their habitat, Natural England may be able to issue a licence to remove and translocate mussels for the purpose of conservation.

In order to issue a licence, Natural England would need to be assured that **(1)** there is no reasonable alternative to the development or maintenance works, **(2)** that there are no other practical solutions which would allow freshwater pearl mussels to be retained at the same location and **(3)** that the actions would make a positive contribution to the species conservation.

In order to apply for a licence to take and translocate mussels for conservation purposes the applicant will have to provide Natural England with the following documents:

- Completed licence application form
- Method statement of the proposed works

This will include the following:

- Details of the planning permission for the proposed development work. If the works does not require planning permission or permits from the regulatory authority then a justification of why the work needs to proceed and why alternatives, which would avoid the need for the movement of mussels, are not suitable.

- Details of the freshwater mussel survey in the area subject to the development proposal/ maintenance works.
- Map showing the area that will be affected by the development proposal/maintenance works.
- Proposed timescale for the translocation of mussels.
- Methodology for moving and holding the mussels.
- Details of the site and map showing where the mussels will be released, including results of surveys undertaken in the area.
- Management plan for the release site (if required).
- Monitoring plan for the release site.

Standing advice has been produced by Natural England and the Environment Agency to assess the effect of development activities on freshwater pearl mussels. Local planning authorities and developers should use this advice to decide what is needed for surveys and plan mitigation measures to protect freshwater pearl mussels. Further details can be found at: **https://www.gov.uk/guidance/freshwater-pearl-mussel-surveys-and-mitigation-for-development-projects**

Rescuing stranded mussels

Section10(3)(a)) of the Wildlife and Countryside Act 1981 provides a defence for certain actions under certain circumstances that otherwise would be an offence – this being:

"the taking of any animal if he/she shows that the animal had been disabled otherwise than by his/her unlawful act and was taken solely for the purpose of tending it and releasing it when no longer disabled".

There may be circumstances where mussels are left stranded and are clearly 'disabled' by means outside the control of the prospective rescuer. Moving stranded mussels is regarded as the most appropriate option to ensure their survival. The defence in the Act only covers the picking up and replacing mussels back into river beds (rescue) by concerned individuals. In order to be covered by the defence the intention must be to replace the animal back in the river i.e. rescue, not to take it for a possible "pearl" content – this would be illegal.

Examples of rescue include:

- Where mussels have been washed onto river banks and gravel bars after flood events.
- In periods of drought conditions where mussels have been cut off from the main river flows and are at risk of death by dehydration.
- Re-depositing of large banks of gravel and eroded soil into the river after heavy winter spates, resulting in the re-routing of the natural river system, cutting off water flow in parts of the channel, thereby threatening the mussels resident there.
- Where mussels have been buried under smothering material or from fallen trees/debris, and thus would continue to be stressed by the causative factor.

Translocation of mussels to another location within the river or temporarily to a hatchery is not covered by the rescue procedure (described above), and, therefore, a full assessment for an application for a license to 'take' will be required.

Advice from specialist Natural England staff should be sought where large numbers of mussels are needing to be rescued. Ongoing monitoring will need to take place in order to assess the success of this work in the longer term.